SURVEYING AND MAPPING

A Quarterly Journal
Devoted to the Advancement of the Sciences
of Surveying and Mapping

Volume IX, No. 1
January–March, 1949

PUBLISHED BY THE
AMERICAN CONGRESS ON SURVEYING AND MAPPING
BOX 470, BENJAMIN FRANKLIN STATION, WASHINGTON 4, D. C.

Jan • Feb • March • 1949

Contents

Volume IX Number 1

Dotting the Dot Map 3
Prof. J. Ross Mackay

Surveyors Need Special Handbook 11
John P. Goggin

Subterranean Surveys 14
William E. Davies

The Hydrographic Office of the United States Navy 18
Guillermo Medina

The Datum of Mean Sea Level 21
H. A. Marmer

Florida State Road Department Re-Mapping Program 28
Jon S. Beazley

Qualifications of a Land Surveyor 39
F. N. Holmquist

Land Surveying Versus Engineering Surveying 42
George D. Henning

Report of Committee on Land Surveying 45
National Council of State Boards of Engineering Examiners

Some Legal Aspects of Property Surveying 47
S. A. Bauer

The Relationship Between the Surveyor and the Title Company 51
James T. Knight

Plastic Relief Models 54
Albert A. Stanley

Surveying and Mapping News
- Current Surveying and Mapping Literature 61
- Distinctive Recent Maps 63
- Books in Review 66

Congress News
- A Legitimate Protest 68
- New Members 68
- Sustaining Members 71

Surveying and Mapping is published quarterly by the American Congress on Surveying and Mappping, Box 470, Benjamin Franklin Station, Washington 4, D. C.

Opinions or assertions expressed in articles in this Journal do not necessarily represent the official views of the Congress.

Dotting the Dot Map

An Analysis of Dot Size, Number, and Visual Tone Density

By J. ROSS MACKAY

ASST. PROFESSOR, DEPT. OF GEOGRAPHY, McGILL UNIV., MONTREAL, QUEBEC

DOT MAPS are often drawn to show distributional data such as dispersed rural population or crop acreages. The field study of an area, or a perusal of statistics, may reveal significant regional variations, yet the dot map which is drawn to illustrate these differences is often disappointing and fails to achieve the purpose of showing diversity in the distribution. The map may be featureless with little contrast between areas which differ markedly in the quantity of the distribution plotted. Nothing is emphasized. The dots in the densest areas are not close together, nor are those in the sparser areas far apart. On the other hand, the dots in the densest areas may unite completely so they can neither be counted nor estimated, whereas those in the sparser areas may still be widely separated. Sometimes the cause may be inherent in the statistics which show too little or too much variation. In such a case a modification of the dot map, or an isopleth map, may be more suitable. Often, however, the cause is due to a lack of balance between the combination of dot size and number.

DOT NUMBER AND SIZE

The selection of the value of the distribution, which every dot is to represent, is of the utmost importance in a dot map. If every dot represents too large a quantity of the distribution, they will be far apart in the denser areas and even more so in the sparser regions. Widely spaced dots usually produce a featureless map (fig. 1) and may imply that there are concentrations of the distribution at the location of the dots. If the number per dot is too small, they may unite to form a black area in the denser regions. Furthermore, the presence of a great many dots may suggest a much higher degree of accuracy in their placing than actually exists. Under average conditions, the dots in the denser areas should be close together or just beginning to coalesce. When an outline map is dotted, consideration should also be given to the final scale of the map, because closely spaced dots tend to clog together on reduction.[1]

Each dot may be placed in the center of gravity of the distribution which it represents, or the dots may be spaced evenly over the smallest areas for which statistical data are being used. If there is supplementary information, such as that which may be derived from an analysis of topographic sheets, the dots may be so placed as to take into consideration regions where the distribution may be sparse or concentrated within the statistical area.[2] Dots may be spaced fairly

[1] E. Raisz discusses dot maps in "General Cartography," 1938, pp. 246–248. See also Brigadier H. St. J. L. Winterbotham, "Dots and Distributions," *Geography*, Vol. 19, 1934, pp. 211–213.

[2] J. K. Wright, "A Method of Mapping Densities of Population: With Cape Cod as an Example," *Geographical Review*, Vol. 26, 1936, pp. 103–110, and Arthur Geddes, "The Population of Bengal, its Distribution and Changes: A Contribution to Geographical Method," *Geographical Journal*, Vol. 89, 1937, pp. 344–361.

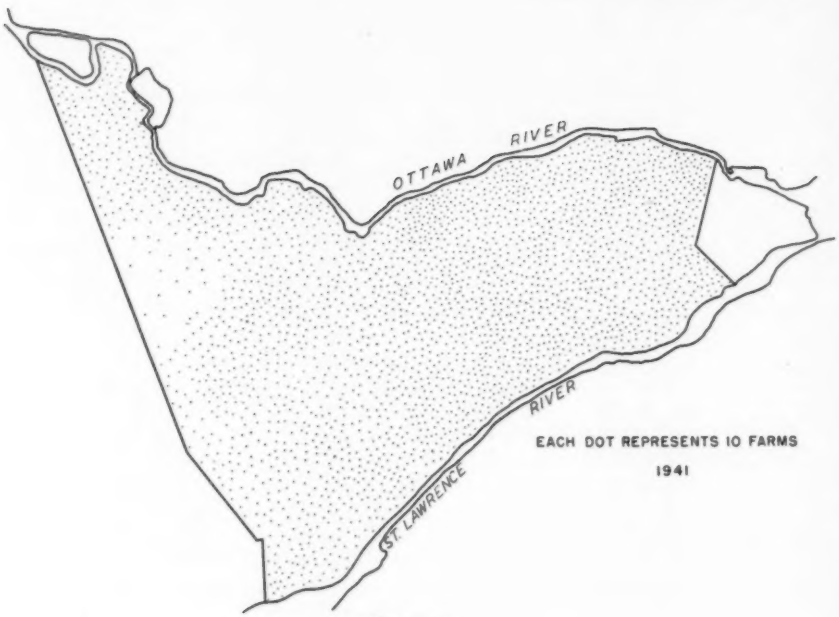


FIGURE 1

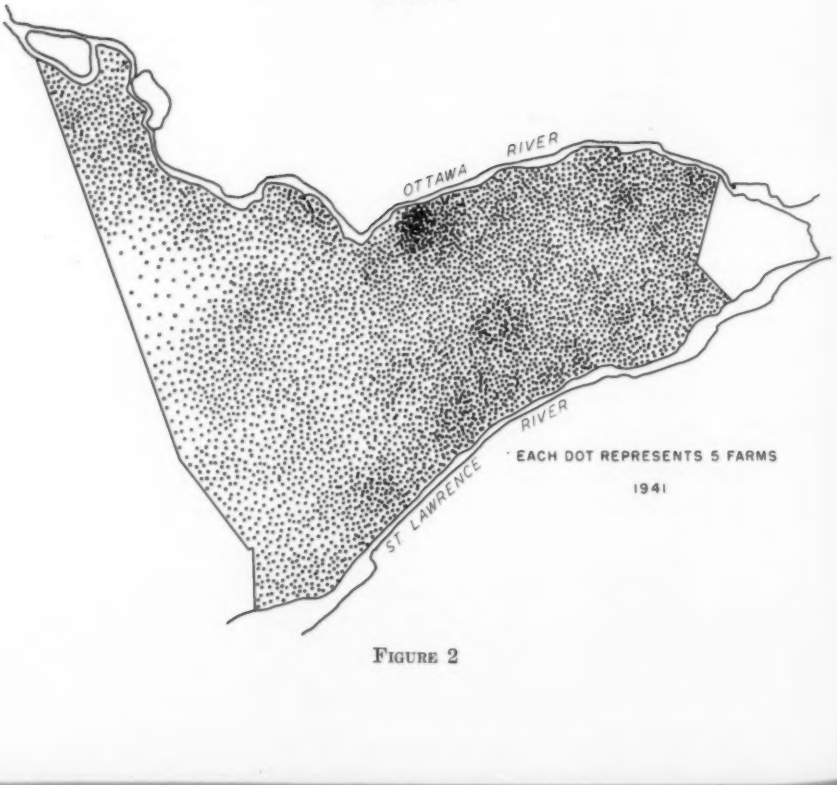


FIGURE 2

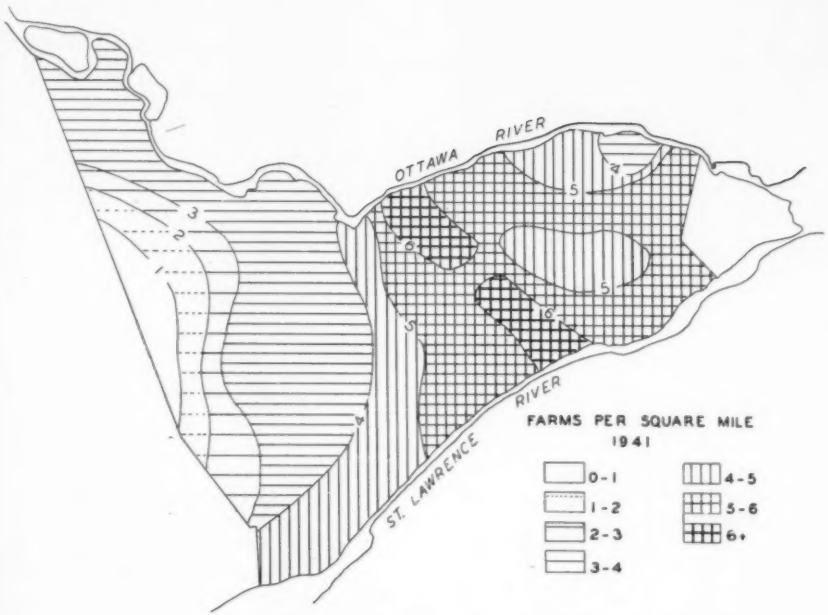


FIGURE 3

COMPARISON OF FIGURES 1, 2, AND 3

These figures were prepared from the same statistical data for 72 townships in Eastern Ontario. Figure 1 shows little contrast between the denser and sparser areas, because the dots are small and generally far apart. It fails completely in showing regional variations. Figure 2 has twice the number of dots as figure 1, and as each dot is 3.7 times the area, the aggregate area of dots in figure 2 is therefore over seven times that of figure 1. Figure 2 shows more contrast between denser and sparser areas than figure 1, and shows regional variations better, but it looks too dark. A compromise between the two maps would probably be the best. Figure 3 is an isopleth map, and shows regional variations better than figures 1 or 2.

uniformly throughout an area on the outline map by placing the first dot near the center and then each successive dot in the largest remaining space. Uniformity of dots may be examined in their areal and linear relationships. Thus dots could be placed in a square or hexagonal pattern. If viewed against the areal or space background, every dot "occupies" the same area, whether a square or hexagonal. The linear relationship between dots is, however, different. In the square pattern every dot is equidistant from the four nearest dots, while in the hexagonal pattern every dot is equidistant from the six nearest dots. The hexagonal pattern is the one which gives the maximum number of dots which are equidistant from all other dots.[3] A formula may be derived for the distance

[3] J. A. Barnes and A. H. Robinson, "A New Method for the Representation of Dispersed Rural Population," *Geographical Review,* Vol. 30, 1940, pp. 134–137, and E. Mather, "A Linear-Distance Map of Farm Population in the United States," *Annals of*

between the centers of the dots if they are arranged in that pattern. If D_C is the distance between the centers of the dots, A the area over which the dots are distributed, and N the number of dots, then:

$$D_C = 1.07 \sqrt{\frac{A}{N}}$$

The preceding formula gives the distance between the centers of the dots, but equally important is the distance between the dots, i.e. between dot circumferences. If D is the distance between the dots, and d the diameter of the dots, then:

$$D = 1.07 \sqrt{\frac{A}{N}} - d$$

In the following discussion it is assumed that evenly spaced dots tend to form a general hexagonal pattern on a map, but it would make little practical difference if the dots were assumed to be in a square pattern and the average distance to the nearest six or eight dots calculated for the value of D.[4] It is, of course, either impossible, impractical or undesirable to space dots absolutely uniformly over an area on the outline map, and some will be closer together than the theoretical value of D, while others will be farther apart. In practice, it is usually possible to add dots to an area until the calculated distance between them approaches a hundreth of an inch, the limiting distance depending upon the skill of the "dotter" and the size of the dots. If all the dots could be accurately spaced, with each dot just touching the 6 nearest dots, the aggregate area of the dots would be 91 percent of the toal area, with the white 9 percent. The amount is independent of the size or number of dots.

Information on dot size[5], number, and distance apart is shown in figure 4. The information is derived by drawing a line from the origin of the graph to the radial scale of dot diameters and then reading the data for dot number, distance between

the Association of American Geographers, Vol. 34, 1944, pp. 173–180. The formula used in the present article is that derived by E. Mather. For an excellent discussion of the problem of evenness of distribution, see J. K. Wright, "Some Measures of Distribution," *Annals of the Association of American Geographers,* Vol. 27, 1937, pp. 177–211.

[4] Twelve 1-inch squares were dotted with different numbers and sizes of dots. The squares were photographically enlarged up to 50 times the area, and the distances between dots measured. The average distances between the dots corresponded closely with the calculated values of D.

[5] Data for dot diameters, made by widely used pens, has been obtained through the courtesy of the manufacturers. The diameters given may be assumed to be representative when a good drawing surface and a good grade of black waterproof drawing ink is used. "LEROY" (Keuffel & Esser Co.) pen sizes 00, 0, 1, 2, 3, 4, 5, 6, and 7 have dot diameters of 0.013, 0.017, 0.021, 0.026, 0.035, 0.043, 0.055, 0.067, and 0.083 inch, respectively. In the case of the "PAYZANT" pen (Keuffel & Esser Co.) the separation of the nibs will be determined by the degree to which the adjusting screw is tightened, but the following figures may be assumed to be average. Pen sizes 8, 7, 6, 5, 4, 3, 2, and 1 have dot diameters of 0.012, 0.018, 0.025, 0.036, 0.046, 0.059, 0.073, and 0.086 inch, respectively. "WRICO" (The Wood-Regan Instrument Company, Inc.) pen sizes 7 and 7A, 6 and 6A, 5 and 5A, 4 and 4A, 3 and 3A, 2 and 2A, have dot diameters of 0.018, 0.025, 0.027, 0.036, 0.048, and 0.062 inch, respectively. The "LEROY" and "WRICO" tubular pens make very uniform circular dots.

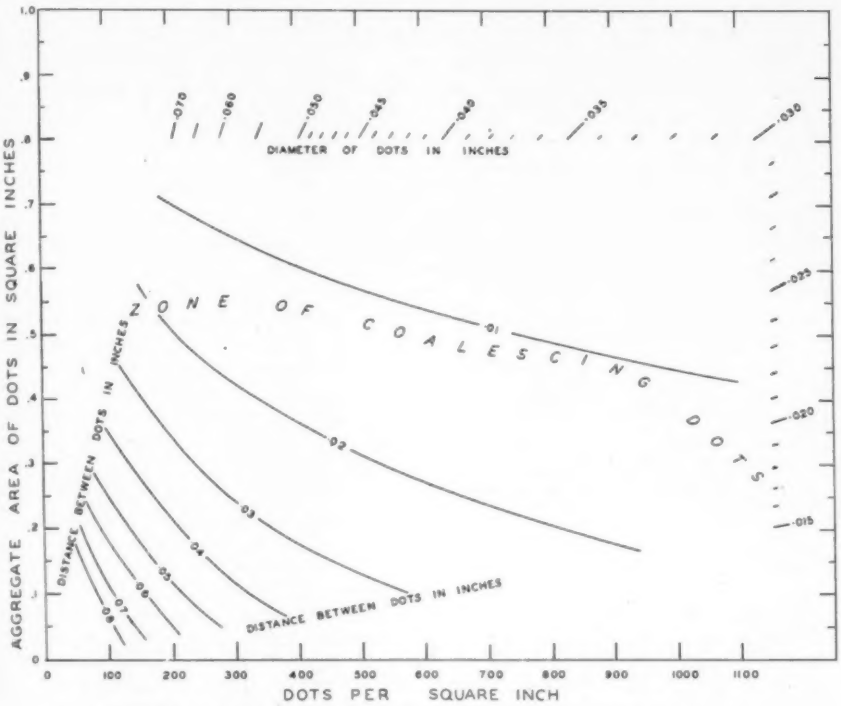


FIGURE 4.—Graph for determining information for various dot sizes.

dots, and aggregate area of dots for any dot diameter. For example, with dot diameter 0.030 inch and 700 dots, the distance between dots will average 0.01 inch, and the aggregate area of the dots will be a little over 0.5 of a square inch. The dots will be so close together that it would be difficult to add more dots without having them coalesce. If it is desired to have the dots average 0.02 inch apart, dot diameters 0.020, 0.030, 0.040, and 0.050 inch could be combined with 700, 450, 300, and 250 dots, respectively. The graph may be used to select dot sizes and numbers to bring out differences between areas. For example, if it is desired to have dots close together in a dense area, which will have, proportionally, five times the number of dots of a sparse area, the following are extreme possibilities for a very small or large dot: (1) dot size 0.015 inch, with about 1100 dots per square inch in the dense area and about 220 dots, spaced about 0.06 inch apart, in the sparse area; and (2) dot size 0.060 inch, with about 200 dots to the square inch in the dense area, and about 40 dots spaced over 0.10 inch apart in the sparse area.

VISUAL TONE DENSITY OF DOT MAPS

If the visual tone density of dot maps depended upon the ratio of black to white, the estimation of tone density would be relatively simple and the gradations could be measured by instrumental means. This is not the case, however,

and any discussion of dot maps must consider the subjective element. Dots aggregating 25, 50, and 75 percent of an area do not produce sensory impressions a quarter, a half, and three-quarters that between white and black. It may easily be demonstrated by experiment that an arithmetic increase of dots in a series of cards, e.g. 100, 200, 300, . . . will not produce a graded sequence to the human eye.[6] When the increase does not exceed 10–15 percent, as from 1000 to 1100, the viewer will probably experience difficulty in detecting the change. Furthermore, it may also be shown by experiment that a proportional increase or decrease, in the number of dots between two areas, will change the visual tone density, and the difference in tone density will not remain constant if the number of dots are unchanged but the dot diameters are varied.

An empirical curve (fig. 5) has been drawn to show the suggested relationship between dots and visual tone density. The general shape of the lower portion of the curve is probably correct, but there has been too little agreement in the experimental results, so far obtained, to justify any claim to accuracy for the upper portion of the curve. No scale of visual tone density is given, because there are too many variable factors to make it feasible, such as the uniformity with which the dots are placed, the size of the dots, the blackness and viscosity of the ink, and the absorbing quality of the drawing surface. In the following paragraphs, an attempt is made to suggest some reasons why tone density varies irregularly with an increase in the number of dots.[7] A comprehensive analysis of the subjective element would require the aid of specialists from sciences which lie beyond the scope of geography.

---

[6] Forty cards, each with circles 2 square inches in area, were dotted with dot diameter .025 inch, and the number of dots was varied between 50 and 1000. Twenty-five individuals attempted to arrange the cards in numerical sequence. Most people had trouble distinguishing dot numbers in cards which differed by less than 10–15 percent in the number of dots. In some cases the reason was partly due to slight variations in spacings or sizes of dots, but these same factors would also be operative in most dot maps, and would affect the judgement of dots in different parts of the maps. Twelve individuals were then asked to arrange 5 of the 40 cards in a graded sequence, beginning with the card which had 50 dots and ending with that having 1000. None of the twelve knew the number of dots on any of the cards, not even the cards with which he was asked to begin and end the series. The results, averaged for the twelve and with the extreme high and low ranges in brackets, were: 50; 137 (110–180); 288 (220–340); 521 (450–600); and 1000. In this and subsequent tests with different sizes and numbers of dots, the graded sequence did not depend upon an arithmetic increase in dots. Andrew C. O'Dell, quoted in "Population Maps: A Discussion . . . opened by Professor C. B. Fawcett," *Geographical Journal*, Vol. 85, 1935, pp. 151–152, stated that in a series of tests which he had conducted, most people considerably underestimated, rather than overestimated, the densities of cards which differed in the number of dots.

[7] Loyd A. Jones has investigated the visual impression produced by ruled lines of different widths and spacings, the results appearing in, "Notes on Statistical Mapping, With Special Reference to the Mapping of Population Phenomena," *American Geographical Society and Population Association of America*, 1938, pp. 21–26. On page 22 he states, ". . . the very presence of the structure (ruled lines) is of itself a factor that modifies profoundly the magnitude of our estimate of the perceptual or sensory difference between two areas (which vary in the amount of black and white)." Experiments have also been conducted to determine with what accuracy people can judge divisions in bar-graphs and pie-graphs, the results appearing in the *Journal of the American Statistical Association*, Vols. 21 and 22, 1926 and 1927.

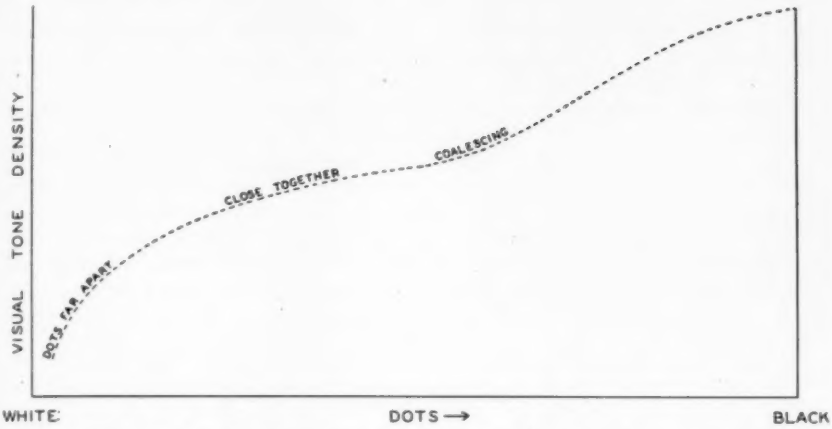


FIGURE 5.—The curve is intended to show the suggested relationship between an increasing number of dots and the visual tone density. No attempt has been made to give a scale either for the visual tone density or dot numbers, because there are too many variable factors to be considered in drawing one curve to suit all conditions.

When the dots are far apart the viewer can observe two distinct items: the spacings of the dots and the individual dots. The distance separating them is a function of dot numbers and size. When the distance between them is varied by an observable amount, the viewer knows there has been a change in numbers, for the dots look "closer together" or "farther apart." This is independent of the visual impression created by the blackness of the dots. For example, pin-pricks could be used instead of dots, and a change in number of pin-pricks could be observed by variations in spacing. If the area remains constant, the distance between dot centers will vary as $\sqrt{\frac{1}{N}}$, that is, inversely as the square root of the number of dots, and the distance between dots will then vary as $\sqrt{\frac{1}{N}} - d$.[8] It is clear, therefore, that it is far easier to detect a decrease in spacing—for equal additions of dots—when dots are few and far apart, than when they are many and close together (fig. 4). Secondly, any specific increase represents a greater proportional change when dots are few instead of many. It would seem, therefore, that a given increase in dots produces a greater visual change in tone density when they are few and far apart, than many and close together, because: (1) the spacings decrease more rapidly, and (2) the actual percent increase is greater.

When the distance separating dots is small, the insertion of additional ones

[8] Some other patterns, like the square, also have the distance between dot centers varying inversely as the square root of the number of dots.

will inevitably cause some to combine.[9] The uniform pattern of closely spaced dots is then broken by the coalesced groups, each of which may be clearly seen. At this stage the tone density apparently changes more rapidly than when the dots are close together, but not coalescing. After they begin to coalesce, an increment of dots will make more and more join together, until there are no longer any individual dots visible, but only discontinuous areas of black and white. Even when no dots are distinguishable, the visual tone density still does not depend upon the ratio of black to white, but upon the number and size of the dots which go to make the areas black. This is because the viewer appreciates that it takes more small dots to make an area black than it does large dots. The subjective element should therefore be the basis for determining the scale and not the mathematical ratio of black to white.[10]

CONCLUSION

A greater understanding of the properties of dot maps may aid the geographer in deciding when and how to use them for showing distributional data. The use of the graphs (figs. 4 and 5) may be of assistance in determining what combinations of dot size and quantity of the distribution per dot will give the desired type of map. This should be especially true of maps where dotting is uniform over divisions on the outline map, rather than where each dot can be accurately placed in the center of gravity of the distribution which it represents. The area of several regions on the outline map can be measured and the corresponding quantities of the distribution per square inch determined. The value of the distribution, which each dot is to represent, and the dot size, may then be chosen so that the dots may be close together, far apart, or coalesce in different areas, as desired. The careful selection of dot size and number is especially important where the range in statistical data is small or large. In the former case, there may be little contrast throughout the map, while in the latter there may be areas devoid of dots, and others completely black. Although it is clear that dot maps do not give an accurate representation of the numbers or ratios of dots (unless they are counted) yet if care is given to their preparation, some of the obvious defects may be minimized and the merits utilized to the best advantage.

---

[9] In figure 4, the zone of coalescing was determined by inserting dots in squares until coalescing took place. Each dot was placed in the largest available space and the square dotted as a whole, rather than by filling out the square by placing each dot next to another. More dots could be inserted in the latter method without coalescing, but the system is rarely, if ever, used in dotting a map. Normally it would be impossible to so judge the spacings and number of dots to cover a region, and have the last dot just fill out the area with none too few or many.

[10] The problem is unlike that of halftone images where the shades of gray are produced by dots, but dots which are too small to be seen with the unaided eye. In halftone images the tone density increases rapidly with an increase in dot area. See "The Relatons between Dot Area, Dot Density and Tone Value for Halftone Images," Technical Bulletin No. 5, *Lithographic Technical Foundation, Inc.*, New York 1945.

Surveyors Need Special Handbook

By JOHN P. GOGGIN

REGISTERED PROFESSIONAL ENGINEER AND LAND SURVEYOR

THE NEED for a single book, written solely for the property surveyor and dealing exclusively with his problems, has been felt among competent surveyors for some time and the Property Surveys Division of the American Congress on Surveying and Mapping has taken upon itself the program of compiling a table of contents for this unique volume. The writer, in accepting chairmanship of the committee responsible for this project, feels that the opinions of as many practicing surveyors as possible will be invaluable in making the decisions as to what the contents of this book should be.

Letters to a number of key men in various states were written, and while all who answered agreed that such a book is vitally necessary, no two of them agreed completely on the table of contents. All were more or less in agreement that there were plenty of texts on "physical surveying" (use and care of instruments, examples of calculations and methods for subdivision of land, etc.); several on laws of surveys and real property, but *nothing on the actual professional practice of land surveying.*

In answer to a separate query regarding the books or parts of books and pamphlets now necessary to properly cover the field of land surveying, most surveyors who answered said they could not afford the time to search through so many books and papers for proper solutions, particularly under the present somewhat unfair competitive conditions. This, among other things, confirmed the belief that a *single* book is necessary and that it is important enough to the profession for the Congress to sponsor the tabulation of contents, and make the scope of the book so universal that the entire practicing profession would aid in its editing.

You can readily see that this is a mammoth task your Property Surveys Division has laid out for itself and it can succeed only with your help. The manner in which you can help has been concisely tabulated by Sol Bauer, Chairman of the Executive Committee, as follows:

1. A tabular listing of subject heads.

2. Lists of books or parts of books now in existence, which you think serve at least in part.

3. A list of tables you think should be contained in such a book.

4. Any special tables or techniques you have developed for your own practice.

5. As many examples of calculations and methods of calculation for subdivision of land, intersection of curves, calculations of areas, etc., as you may have.

6. Your methods of keeping field notes for various types of work.

7. Those fundamentals of law that you think are of predominant importance in property survey work.

8. Your opinions on such subjects as the responsibility of the property surveyor, both from the legal and business points of view.

9. Any other matters important in the practice of property surveying.

This new program is of extreme importance, and the value of the result is dependent

upon your support. Mr. Goggin is willing to be "snowed under" with your material. Please accommodate him.

SUBJECT MATTER TO BE INCLUDED

We are led to believe that the subject matter in the book should include:

Registration laws and minimum examination requirements; ethics (expert witness, old surveys, fees, relations with other surveyors, etc.).

Legal principles (description, accretion, etc.).

Public relations (ethically convincing laymen that there is no such thing as cheap service).

Surveyor's legal responsibility.

Duties of the surveyor vs. the lawyer.

County Surveyor's duties, requirements and responsibilities.

Standards of Practice (what constitutes a legal survey and the method of performing it).

Suggested local laws affecting the manner of subdividing land, leading ultimately to national and international legal standards.

Other suggestions received are as follows:

History, giving establishment of various facts.

Progress of the surveys.

Copies of the original instructions showing evolution of the various phases.

A development of field techniques, standards, permissible errors, etc.

A thorough discussion of retracement procedure emphasizing the need for a complete understanding of the steps that were followed in the original survey of the tract in question as well as a knowledge of subsequent surveys.

General requirements of operation of the surveyor both in field and office including methods of obtaining necessary information and consultation with clients.

Names, illustrations, uses and care of all instruments.

Field and office practice in running lines.

Traverses, common triangulation, search and discovery and verification of monuments.

Methods of layout of subdivisions or particular parcels of land.

Levels, contours, planetable, stadia, and direct angle-distance method for topographic work.

Formulas: general, trigonometric, special for certain type problems.

Calculation processes: simple, short methods, approximations, graphs, diagrams, general and special tables.

Map making: scales, details, topography, legal requirements for certificates on maps, use, reproduction processes.

Drawing and interpretation of land and property descriptions, and the legal aspects applying thereto, including proper field location and monumentation of described land.

Legal requirements for the practice of land surveying in the state.

Requirements for the filing of maps of record.

Nature and presentation of testimony as a witness in court on matters of land location.

General features of costs, fees, ethics.

Existing forms of land subdivision (sectional, town plats, resurveys of small areas, etc.).

Establishment of base of survey, astronomical observations, bearings, azimuths.

Explanation of use and connections with lines and monuments of the State Coordinate System together with methods of incorporating values into the records using maps.

Topically indexed list of references and books for more complete information on procedure and equipment required in special or unusual types of survey.

You will note that the land surveyor needs much more training and education than mere ability to measure a line and turn an angle. The above qualifications, although applicable in part to other phases of engineering, are *all* necessary to the proper exercise of a land surveyor's activities.

Please send us *your* suggested table of contents.

What type of examples do you think should be shown in the book? Will you send us some? Do you have any suggestions for indexing and cross-indexing that would facilitate use of the book? Do you think the book should be semitechnical only; its major theme being professional procedures and practices and containing merely a technical bibliography? What do you think of stating a problem, giving its solution and then referring to court decisions leading to the given solution?

We sincerely hope that this article has provoked much thought and engendered many questions. If so, just jot them down and forward them. They need not even be formally written. We are interested in the material not the style of presentation.

If you honestly believe that such a book is important and necessary, please follow Mr. Bauer's suggestion and literally "snow us under" with your material. You may send it direct to me at Box 28, Clare, Michigan.

❦ ❦ ❦

Reprints of Technical Standards Now Available

THE Property Surveys Division announces that reprints of the TECHNICAL STANDARDS FOR PROPERTY SURVEYS in letter insert form are now available for quantity sale. Many practitioners have found these reprints of value as inserts to accompany proposals, estimates and reports on survey matters.

Reprints are available at the following prices:

10	reprints	$1.00
50	"	2.50
100	"	4.00

They may be obtained from the chairman of the Property Surveys Division, S. A. Bauer, 1836 Euclid Avenue, Cleveland 15, Ohio. Orders for the reprints should be accompanied by check made payable to The American Congress on Surveying and Mapping.

Subterranean Surveys

By WILLIAM E. DAVIES
CHIEF, RESEARCH SECTION, ARMY MAP SERVICE

WITHIN the past two years the American public has become extremely cave conscious, but with this sudden rise of interest there has also risen an air of mysticism, awe, and general misunderstanding of cavern conditions. It is the object of this article to assist in clarifying this subject, especially the important phase of subterranean surveys.

Cavern exploration is not a new field. Probably every child living in a limestone area has ventured into caverns and, like Tom Sawyer, has used caves as a place for play. In Europe cave study has long been carried on as a recognized science. In France an organized society to promote speleology has existed since 1895. Similar organizations in Germany, Italy, England, and Austria have existed for a quarter of a century.

Cave interest in the United States has lagged considerably behind that of Europe. No organization existed to promote cave research until 1940, the date of the founding of the National Speleological Society. Since the formation of that Society rapid progress has been made in cave exploration and research. Detailed studies have been completed of Pennsylvania and Maryland, and a study of West Virginia is now underway. Extensive work in Missouri, Virginia, New York, Georgia, Indiana, and the New England States is also in progress.

Speleology has changed from a purely scientific study to one with many practical applications. Military use has been an important consideration in the past three years. Because the average person's knowledge of caves and cavern conditions is extremely limited there has been much misunderstanding concerning their military use. Many people believe that caves offer a means of defense in atomic warfare. This is very erroneous, for the known caves are too few in number to provide sufficient shelter for machines, goods, and people. The number suitable for storage or shelter is further reduced by the inaccessibility of many caves and the rough terrain encountered in their interiors. If war is imminent caves will be used, not for the shelter of people but rather for the storage of irreplaceable documents, machines, and the like.

Economically caverns offer bright prospects. Already two caverns in the Midwest are in use as storage tanks for natural gas under high pressure. In the future, the underground storage of natural gas and refined petroleum may be greatly increased. Cheapness of construction, low maintenance and depreciation costs, and low insurance rates play an important part in such underground installations.

The average person has seen only the commercial or developed cave. Here smooth walks, electric lights, and cleared passages permit easy access and traverse. This condition is hardly that encountered in the undeveloped cavern.

If the surveyor were to confine his work to a narrow canyon, working only at night, in high humidity, and on ground covered by the stickiest of mud, he might approach physical conditions comparable to those underground.

Presented at Eighth Annual Meeting, American Congress on Surveying and Mapping, Washington, D. C., June 21–23, 1948.

In general, the passages in caves consist of either long tunnels or alternating tunnels and chambers. Passages vary greatly, ranging from low, narrow sections, which necessitate crawling on all fours, up to giant clefts over a hundred feet high and equally wide. Generally the passages are on more than one level, connected by large vertical drops, many of which are difficult to pass. The floors are generally uneven, being covered with boulders and slabs of rock that have fallen from the ceiling. Occasionally they are dry, but in many cases mud with the consistency of putty covers the floor. At times the walls are covered with a sticky or slimy substance. Active streams are encountered in many caves. They vary in size from small, shallow brooks, occupying a portion of the floor, to large rivers, many feet deep, that completely fill the passage.

Cave patterns generally follow a geometric system. In some cases the pattern will be that of a single long tunnel, in others, a series of parallel tunnels. In extreme cases a maze of passages at right angles, forming a grilled pattern, are found.

In depth, caverns range from shallow passages, that never drop much below the level of the entrance, to deep passages, that seem intent upon reaching the center of the earth in a minimum number of vertical drops. In the latter type, vertical drops measuring hundreds of feet, are often encountered. These drops increase the difficulty of the surveyor's work. A large survey party with extensive equipment is necessary if such drops are to be successfully passed. It is in such instances that mountaineering experience becomes useful.

To provide a basis for planning the economic or military use of caves, as well as for scientific work, it is necessary to conduct detailed surveys.

The type of survey and instruments used depends on the size and condition of the cave. Transit and planetable surveys are used in the larger caves, but such surveys are far from simple. Instruments present a serious problem to the cavern surveyor. Though standard instruments are satisfactorily protected for surface work, they are subject to short life in caves. Corrosion from cave waters and mud is severe and will often damage the instrument in one trip underground. Recent trends toward the use of aluminum and magnesium metals further aggravate the problem, as they are subject to rapid corrosion. Entire parts of such instruments are frequently dissolved in a few trips underground. Chrome steel and similar corrosive resisting metals are satisfactory in most cases, but, unfortunately, they are found less and less in modern instruments.

In caves made up of large rooms, and having a minimum of narrow passages, planetable or transit surveys are practical. Such surveys are conducted in a manner similar to those on the surface, except that illuminated stadia rods are used.

In smaller and more broken caves compass and tape surveys are the most practical. Tapes of 100-foot lengths are generally used, as it is seldom possible to get sights of greater length. Direct reading compasses are preferable as they simplify the keeping of notes. Brunton compasses, while ideal from a technical standpoint, are limited in use because of the aluminum used in their construction.

Increased interest in the economic use of caves has given impetus to subterranean surveys in recent years, and attention has been directed to developing special survey instruments for this purpose. Range finders, similar to those used in photography, have been adapted to underground surveys, but are limited in use due to the necessity of having a light source at the point being estab-

lished. Often such points are separated from the instruments by pits or other difficult features, which makes it either dangerous or excessively time-consuming to establish a light source at the point. Instruments with a light source to project a focussed spot on the point, coupled with a viewing telescope in the form of a short base range finder, make cavern surveying easier and far more rapid. Elevation changes of the cave floor are generally obtained by using the hand level. The accuracy of altimeters or barometers for level work in caves is questionable. The reaction of barometers to cave conditions has received little study; but experience indicates that when barometer and stadia level are run concurrently, there is a marked discrepancy in the results. Barometers tend to exaggerate depths as much as 20 feet in 100. The greatest errors occur at vertical drops and are probably the result of the rapid change in humidity and carbon dioxide content of the air.

In actual practice, cave surveys differ slightly from ground measurements. The most striking difference is in the surface measured. Normal surveying is confined to delineating the exterior surface of the earth, whereas the underground surveyor must measure the interior surface of an enclosed void. This necessitates mapping the cavern ceiling which, at times, presents a difficult problem. In order to simplify this problem the ceiling is mapped with reference to the cavern floor, and the shape, position, and slope of the ceiling are shown only where they differ radically from that of the floor. Contouring, when shown, is confined to the floor. If carried throughout the walls and ceiling there results a curious series of closely spaced, closed contours that defy interpretations.

Ceiling heights are obtained in many ways. Where the cave is small, or the the ceiling low, an ordinary extension rule can be used. In caves with high ceilings the procedure is more difficult. If transit or similar instrument surveys are being run, the height can be determined by intersection. However, a serious limitation exists in the use of instruments, or range finders, as some ceilings are of such height that hand light will not properly illuminate them. A rather simple solution exists for this condition. A child's balloon, filled with hydrogen, and attached to a light, can be used to measure ceilings rapidly and with accepted accuracy.

A second difference results from the fact that most caves are in the form of a series of tunnels which limits the area to be surveyed. Two methods of surveying are commonly used in such caverns. In one a series of primary stations are occupied, and from each of these stations a series of sights are taken to all salient features. The other, and by far the most rapid method, makes use of a series of primary stations with secondary stations established along the line of sight, opposite salient points. The positions of the salient points are given in their distance at right angles from the line of sight. This method greatly reduces the number of bearings to be read and reduces to a minimum the number of stations to be established.

The use of photographs in cave mapping is receiving increasing attention. It is rather common to find that photographs taken in caves reveal far more detail than the individual observes. The detail is utilized in a manner similar to that of terrestrial photogrammetry. Making the photographs however, is quite expensive, as it is necessary to use flash bulbs in more than one position on each shot to eliminate obscuring shadows.

Cave maps vary somewhat in design according to the physical aspects of the cave. Caves that are primarily vertical are shown by detailed profiles and cross sections, while those that are mainly horizontal are delineated by detailed plans accompanied by generalized profile and cross sections. Most caves in the United States are horizontal in extent and, therefore, the latter method of portrayal is universally used. In England and to some extent in France the opposite is true.

The scale of maps has become somewhat standardized through use. Wherever possible, a scale of 1 inch to 10 feet is used. However, in the larger caves 1 inch to 40 or 50 feet is common. Seldom are scales of less than 1 inch to 100 feet used. Such scales, when used underground, have proved very satisfactory, but they present a problem when the cave is mapped with relation to surface features, for then large areas of the surface must be surveyed at the same scale.

Symbolization for cave maps differs considerably from that on normal surface maps. However, the symbols used, like the scale of cave maps, have become standard through use. In large caverns contours at times are used to indicate the terrain of the floor. In smaller caves the use of elevation numbers and slope figures replace the contouring. Because of the importance of vertical drops, slopes, shelves, and similar features in caverns, it is necessary to provide a number of special symbols to show them in detail. Symbols are also provided for various types of cavern formations, as stalactites, flow stone, and stalagmites, and to indicate whether the floor is gravel, sand clay, or boulders.

The datum point for most cave levels is the entrance. On cave maps the elevation of the floor at significant points is indicated by appropriately spaced figures. Ceiling heights are generally indicated by a figure enclosed in a circle.

Caves that are made up of more than one level are difficult to depict on a map, especially if the levels lie one over the other for much of their distance. Most cave maps distinguish different levels by the use of varying weights and types of lines for each level. Different colors are sometimes used to indicate these levels, but this method makes reproduction of the map expensive.

Standardization of cave maps has been carried on internationally to quite an extent. The British Speleological Association and the National Speleological Society, here in the United States, have agreed upon standard specifications for cave maps. Italy and France, in general, have specifications that agree closely with those of the American and British. This standardization has developed from the normal trend in cave surveying, international correspondence, and the fact that cavern conditions are much the same throughout the world.

Only the high points of cave surveys and maps have been discussed in this article. To those who may have the opportunity to do work underground it is assured that the job is not so difficult and dangerous as to make it one to be avoided. The work is fascinating, though strenuous, and it is one of the few activities in which both sport and science find equal expression.

THE NINTH ANNUAL MEETING, JUNE 8–10, 1949, WASH., D. C.

The Hydrographic Office of the United States Navy

By GUILLERMO MEDINA

CHIEF ENGINEER, U. S. HYDROGRAPHIC OFFICE

FOR OVER ONE HUNDRED YEARS the Hydrographic Office has served our Navy and Merchant Marine by providing nautical charts and related publications calculated to safeguard navigation throughout the world. The high reputation our products have with mariners under every flag is a tribute to the excellence of American cartography. Both the U. S. Coast and Geodetic Survey and the Hydrographic Office of the United States Navy have strived to make the task of the navigator as easy as possible by portraying hydrographic information in a clear, accurate, and artistic manner. We can truthfully state that American charts are among the best in the world. The principal reason for this is our desire to be of maximum service. By providing the best available tool required by the navigator, which is a good and accurate chart, we are accomplishing our aim.

In reality, a chart is a navigational instrument of precision which must be kept in top operating condition at all times. Safety at sea depends to a large extent on the reliability and up-to-date condition of the information it portrays. It must be correct for the latest information. Herein lies one of the main differences between a chart and a map. Thus, it is necessary for hydrographic establishments to print their products at frequent intervals and in limited quantities—as each chart must be kept corrected by hand to date of issue. To do otherwise would be an uneconomical and wasteful practice. In addition, a service must be provided whereby the mariner can be kept informed constantly of vital information affecting the charts in order that this can be incorporated on them without delay. On the other hand, a map is not intended for navigation and is usually printed in very large editions without the benefit of a maintenance service for the user.

Hydrographic surveying and charting are specialized branches of engineering which not only require major funds for their execution, but also personnel with certain special qualifications. Only governments can assume the tremendous task of surveying the coastal areas and the water expanses that cover the surface of the globe. Despite the fact that considerable work has been done in this respect by the major maritime nations of the world, much remains to be done before we can consider that adequate world-wide chart coverage is available. One of the principal reasons for the present inadequate situation is the fact that a large percentage of existing charts are based on surveys carried out nearly a century ago when the size, draft, and speed of ships plying the oceans were only a fraction of what they are today.

It must also be remembered that inadequate equipment made the task of the surveyors of the past century an arduous and time-consuming operation.

Presented at Eighth Annual Meeting, American Congress on Surveying and Mapping, Washington, D. C., June 21–23, 1948.

Today we have—besides better and faster surveying craft of all types—a number of scientific advances which have truly revolutionized this field of engineering. Echo sounding, electronics, aerial photography, and better surveying techniques and equipment have not only reduced the cost and improved the efficiency of a hydrographic expedition, but in addition have made it possible to increase the accuracy and wealth of detail essential for safe navigation.

Charts, like maps, serve not only a peacetime purpose, but without doubt are the most important weapon available for offense and defense. Military operations are planned and executed in the graphical portrayal of the earth provided by them. Naval strategy and the support rendered in transporting men and munitions of war to the far corners of the earth demand accurate charts in sufficient quantities to successfully support any operation on land, at sea, and in the air.

A nautical chart must not only cover the hidden submarine topography and the dangers and aids to navigation, but also the coasts and the topographic features bordering them. It is the most comprehensive presentation of a portion of the globe. It is accurately controlled by a geodetic net referenced to an astronomical datum and with all hydrographic detail reduced to a common datum. Bathymetry serves as a counterpart of topography to give the mariner, the geologist, and the geophysicist a continuous relationship of the land and water features, the latter offering serious problems due to the long distances involved and the necessity of accurate control at all times. The hydrographic engineer has to rely on special equipment and complex methods—many of them time consuming—to extract the data necessary to chart the intricate submarine topography that lies hidden beneath the surface of the sea. He has to be an expert in both fields of surveying, with the endurance of a mountain goat and the stomach of a denizen of the sea.

The U.S.S. *Tanner* and the U.S.S. *Maury,* our two main survey vessels, and their auxiliaries, are outfitted with the latest available sonic, electronic, and oceanographic devices. With their long cruising radius and ample working and storage space they are able to carry out surveying operations far from our home shores. Complete reproduction equipment on board makes it possible to produce field charts in standard colors as the work progresses. This latter feature is of the utmost importance in wartime, as it permits the printing of charts based on the latest information for use by a striking force.

As an added essential auxiliary each expedition carries an airplane, which soon will be replaced by a helicopter of the latest design. This serves the purpose of carrying out the reconnaissance of the territory being surveyed, for supplemental aerial photography, and for the transportation of personnel to remote locations.

It will be seen from this general description that naval survey expeditions are ideally equipped.

Here in Washington the Hydrographic Office, under the command of Rear Admiral R. I. Glover, Hydrographer of the Navy, serves not only the Navy but the Merchant Marine as well. In addition, it gives collateral support to the other departments of the Armed Services. With over five thousand nautical charts and other related publications on issue, it gives a service unique in kind and vast in scope. Twenty-four hours a day and all through the year it keeps

in touch with shipping throughout the entire world by radio, daily memorandum, and weekly Notice to Mariners.

Our plant is complete to the finest detail. New techniques and new mediums developed at the Hydrographic Office during the past few years have made it possible to decrease cost of production and materially increase our output. The Duco and plastic method of chart construction has played a major part both in nautical and aeronautical work not only in the preparation of the originals, but also in the reproduction of the charts.

Despite the advancements made thus far in the art of cartography, some problems must be solved in the near future in order to keep pace with the electronic developments of the past few years.

Other problems in the numerous fields in which the Hydrographic Office is engaged are under constant study as only in this manner can our products keep abreast of the expanding needs of the nation and its navigators to whom we are pledged to serve to the best of our ability.

The Hydrographic Office offers varied opportunities as well as a brilliant future to young engineers who are willing to work hard in the interest of safety at sea and in the air and who believe that charts are essential for commerce and more important still, for the security of America.

Attention Contributors!

CONTRIBUTORS to SURVEYING AND MAPPING who desire reprints of articles are requested to order them at the time their manuscripts are submitted. The publisher requires the Editor to place all orders for reprints with the return of the corrected galley proof, otherwise the type is dismantled and the regular reprint rates no longer apply.

The present reprint costs for 8-page articles (including covers) are approximately as follows:

50 reprints	$25.00
100 reprints	30.00
Additional units of 100	5.00

Four-page articles are proportionately less.

—EDITOR

The Datum of Mean Sea Level

By H. A. MARMER

ASST. CHIEF, DIV. OF TIDES AND CURRENTS, U. S. COAST AND GEODETIC SURVEY

IN surveying and mapping, mean sea level is the most commonly used datum for elevations. This datum is of simple definition: obviously, it must be determined at some point along the sea coast, and at any point along the coast it is simply defined as the mean level of the sea at that point.

Now the level of the sea at any place varies continually in response to the disturbing effects of tide and wind, and of changes in atmospheric pressure and in the temperature and density of the water. Of these, the tide is generally the predominating influence; and since the tide is periodic with a primary period of a day, we can get a first approximation to mean sea level by averaging the changing level of the sea over the period of a day.

In determining mean sea level at any point by averaging the changing level of the sea, it must be noted that we are determining not a scale reading on an instrument with a fixed zero, but the location of a horizontal plane on the earth. In measuring the changing level of the sea on a graduated rod or tide staff, the scale readings have meaning only when related to some fixed point on land. This means that the tide staff must be maintained at a constant elevation by reference to a number of adequate bench marks.

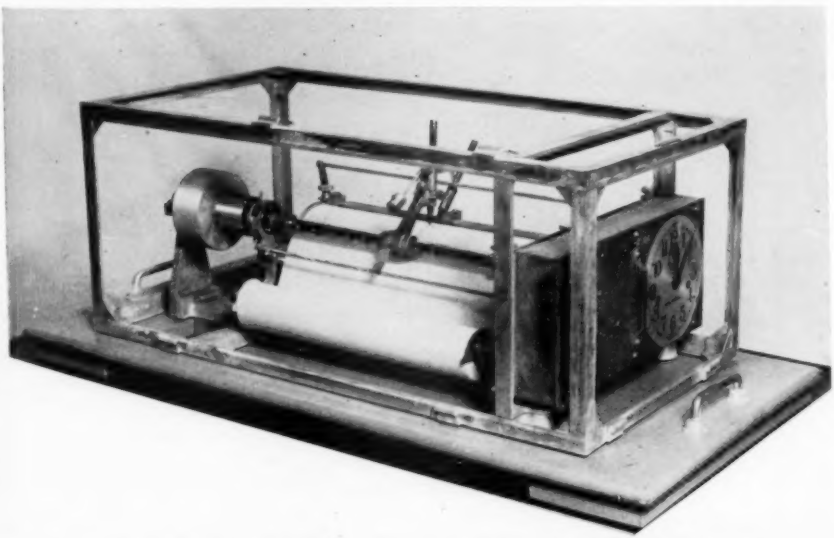


FIGURE 1.—Automatic tide gage for measuring the rise and fall of the sea.

Presented at Eighth Annual Meeting, American Congress on Surveying and Mapping, Washington, D. C., June 21–23, 1948.

The most effective method for measuring the changing level of the sea for the purpose of deriving mean sea level is through the use of an automatic tide gage which makes a continuous record of the rise and fall of the surface of the sea. From this record we can determine the height of the sea at each hour, and from these hourly heights we can derive the average height for as long a period as may be desired.

FLUCTUATIONS OF SEA LEVEL

The question that immediately arises is, for how long a period of time must we average the changing level of the sea to arrive at a determination of mean sea level? A first approximation is obviously given by averaging the hourly heights over the period of a day, which eliminates the tidal fluctuation.

If we average the hourly heights of the sea at any place for each day for a number of days, we find that sea level fluctuates from day to day by amounts varying from less than a tenth of a foot to more than a foot. Furthermore, during a single month, sea level on one day may differ by more than 2 feet from that on another day. And during a year, two daily sea levels may differ by 3 feet or more.

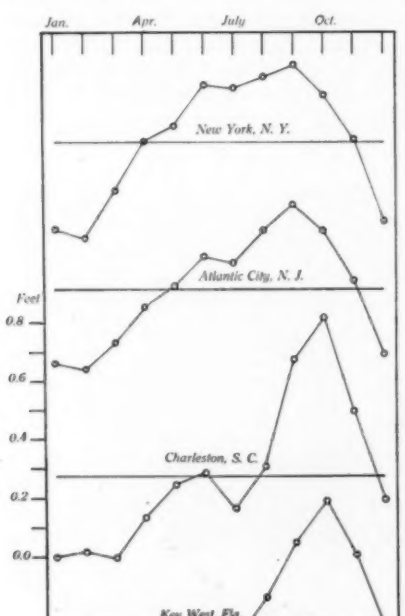


FIGURE 2.—Monthly variation in sea level, Atlantic coast stations.

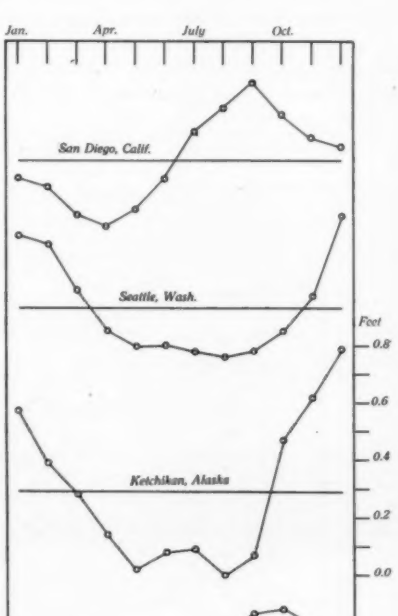


FIGURE 3.—Monthly variation in sea level, Pacific coast stations.

These relatively large variations in daily sea level are obviously to be ascribed to the effects of wind and weather which vary throughout the year. It follows, therefore, that sea level determined from 1 day of observations can give only a rough approximation to a mean value. To determine mean sea level with any pretense to accuracy, a longer series of observations is necessary and a month suggests itself as a possibly desirable period.

In deriving sea level for a month we are deriving the average of some 700 hourly heights. If now we investigate monthly sea level we find that from one month to another it may vary by nearly half a foot, while within a year two values of monthly sea level may differ by nearly a foot. Since the seasonal change in wind and weather is largely periodic, the question arises whether the change in monthly sea level is not largely periodic?

On investigation this is found to be the case. In figure 2 are shown the average monthly heights of sea level at four stations on the Atlantic coast and in figure 3 at four stations on the Pacific coast of the United States. For each station the monthly means are based on 20 years of observation, and the horizontal line represents mean sea level at each station.

The periodic seasonal variation is seen to differ at different stations, but at places relatively near each other, as for example New York and Atlantic City, the variation is much the same. The range of this periodic variation at many places is more than half a foot and at places subject to river flow it may be much larger.

In view of both the periodic and non-periodic variations in sea level from month to month, which are characteristic features the world over, it is clear that a month of observations will not give a very precise determination of mean sea level. A year immediately suggests itself as a desirable period, for within a year the seasonal variation will be eliminated and the disturbing effects of wind and weather tend to balance out.

In figure 4 are shown the yearly values of sea level at four stations on the Atlantic coast of the United States for which observations are available for 25 years or more. At each station the yearly height is the average of the hourly heights of the sea at that station for the year in question. In other words, each yearly height is the average of nearly 9000 hourly heights.

Disregarding for the moment the dashed-line curve associated with the diagram for each station, it is seen that sea level varies from year to year. To be sure, this variation is relatively small, generally less than a tenth of a foot; but occasionally it may be as much as two-tenths of a foot. Moreover in recent years there appears to be a slow progressive change, so that within a 20-year period sea level determined in one year may be half a foot different from that determined in another year.

The fluctuations from year to year are due primarily to the disturbing effects of wind and weather. These may be largely eliminated by smoothing the yearly values by the method of moving means and then drawing a more or less smooth curve through these means. These smoothed curves are represented by the dashed-line curves associated with each of the diagrams. At all four stations shown in figure 4 it is seen that there has been a steady and progressive rise in sea level since 1930 at the rate of approximately 0.02 foot per year.

The fluctuations in sea level from year to year and the progressive rise in

recent years is not confined to the Atlantic coast. Figure 5 gives the records of the yearly sea levels at four stations on the Pacific coast of the United States. From year to year the fluctuations here are much the same as on the Atlantic coast, but the progressive rise in sea level in recent years is less than on the

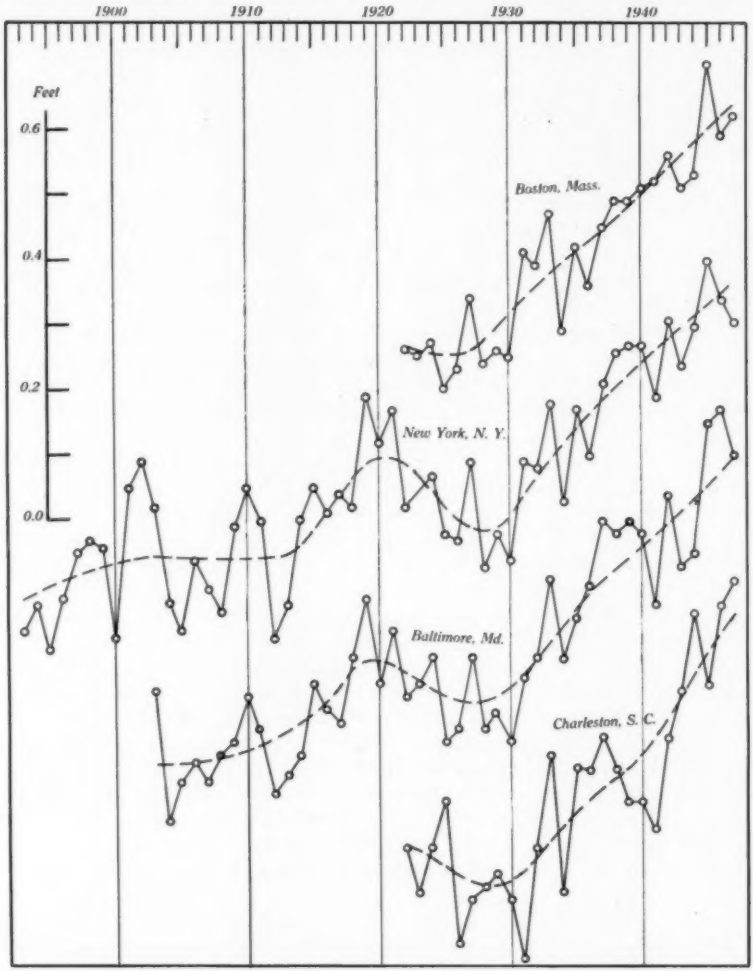


FIGURE 4.—Yearly sea level, Atlantic coast.

Atlantic coast. The differences in yearly sea level that may occur in a 20-year period are illustrated by the data for San Francisco for the years 1924 and 1941 when the two values differed by 0.65 foot.

The diagram for Ketchikan, Alaska, is of interest in that it directs attention

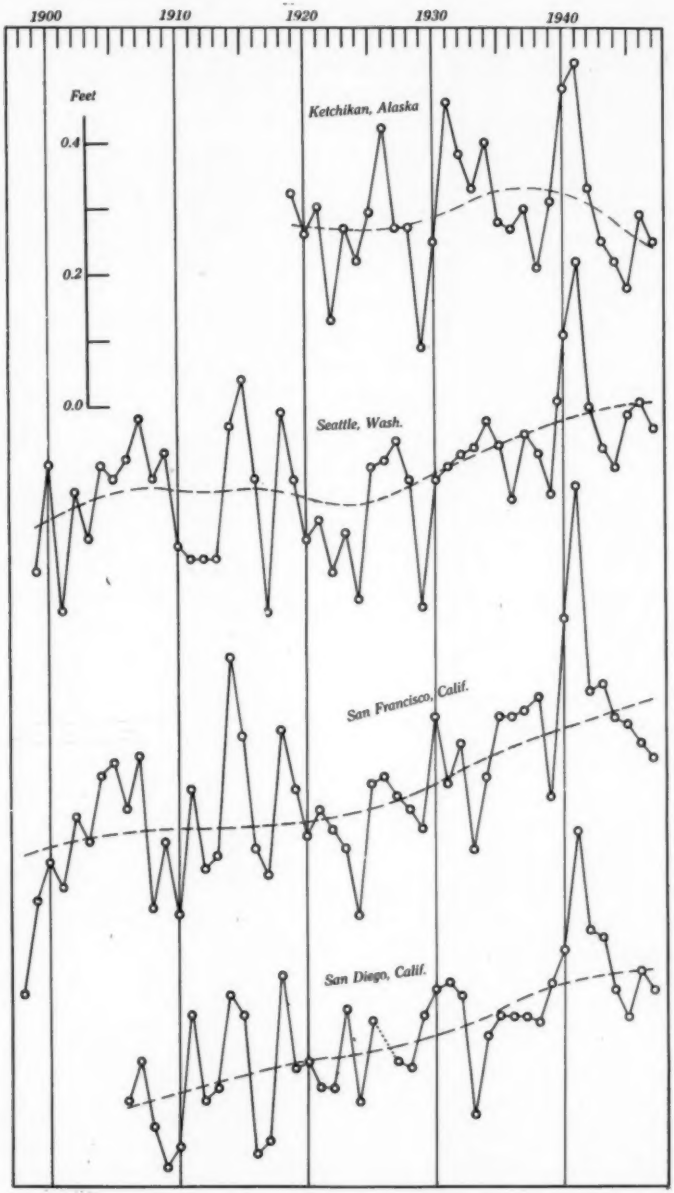


FIGURE 5.—Yearly sea level, Pacific coast.

to the fact that sea level at certain places may rise for a number of years and then commence to fall. Sea level at Ketchikan from 1919 to 1936 rose about 0.05 foot and since the latter date has fallen about 0.09 foot. This fall appears to be a real fall in sea level with respect to local bench marks, for a large region in southeastern Alaska has been rising in recent years.

DETERMINATION OF MEAN SEA LEVEL

We may summarize our discussion of sea level to this point by saying that sea level fluctuates from day to day, month to month, and year to year. In addition there are also slow secular changes in sea level, rising in some places, falling in others. In all this welter of fluctuation and change, how can we determine a precise datum of mean sea level?

To begin with, we must note that the concept of mean sea level as a fixed and unchanging elevation good for all time on this continually changing earth is not a valid concept. Instead we must adopt a mean sea level based on a definite number of years, and referred to a given epoch. As soon as we do these two things, everything is in the clear.

There is a small periodic variation in sea level depending on the longitude of the moon's node, which has a period of 18.6 years. Hence we may take 19 years of sea level as constituting a primary determination of the datum. As for epoch, any epoch agreed upon will serve, and in the Coast and Geodetic Survey we are using the epoch 1924–1942.

With the adoption of a definite number of years as constituting a primary determination of mean sea level and basing it on a given epoch, we not only make of mean sea level a precise datum, but we are also in a position to correlate this datum for large regions without the necessity of making 19 years of observations at all places where this datum may be desired. An example will make this clear.

Referring to figure 4, suppose we had determined mean sea level from a year of observations at Boston in 1925, and we fixed it by referring it to a substantial bench mark which was found to be exactly 10.72 feet above mean sea level. In 1945 another year of observations was made and referred to the same bench mark. Now, however, it is found the bench mark is 10.22 feet above mean sea level, differing from the determination in 1925 by exactly half a foot. From these two sets of observations alone we wouldn't know whether the bench mark may not have changed during the intervening years. And even if we did have other evidence substantiating the stability of the bench mark, we would still be at a loss to know on which year of observations to base our mean sea level.

However, we know that sea level fluctuates from year to year and we should like our mean sea level to approximate a 19-year mean. We do have a 19-year series based on the epoch 1924–1942 at New York. For the year 1925 we find that sea level at New York was 0.13 foot below its 19-year value, while in 1945 it was 0.29 foot above its 19-year value. And although New York is nearly 200 miles away from Boston and in a different embayment of the coast, we know that the fluctuations in sea level all along the stretch of coast from Boston to New York are much the same. Hence to correct the 1925 and 1945 observations at Boston to the 19-year mean we must add 0.13 foot to the 1925 value and subtract 0.29 foot from the 1945 value. As a result mean sea level from the 1925 observations becomes 10.59 below the B.M. and from the 1945 observations 10.51.

So that the two yearly sea levels which differed by half a foot yield mean sea level values differing by only 0.08 foot.

We can check our results further in this particular case, for we have tide observations at Boston for the 19-year period 1924–1942. From these 19 years mean sea level comes out as 10.54 feet below our B.M. The 1925 observations corrected by reference to New York thus give mean sea level within 0.05 foot of its mean value while the 1945 observations give it within 0.03 foot.

Basing the datum of mean sea level on a definite number of years and on a given epoch makes of it a precise geophysical datum.

❦ ❦ ❦

Find Oil Off U. S. Coast

LARGE PETROLEUM ACCUMULATIONS exist under the American continental shelf and it is physically possible to get the oil from them, the American Petroleum Institute was told in Chicago by Mercer H. Parks and James C. Posgate of the Humble Oil and Refining Company.

Continenal shelf petroleum production has passed the initial planning stage and as a result of successful drilling operations, at least two oil discoveries of possible major importance have been made, they said. These are both in the Gulf of Mexico.

Operations in open water encounted problems of the elements in addition to those usual on land. Auxiliary operations, such as transportation and drilling site preparations, they stated, become major items from technical and financial viewpoints.

The drilling sites now in use involve large platforms capable of supporting everything needed for drilling operations, as well as smaller platforms serviced by floating barges in a manner similar to that used in sheltered waters.

The two oil discoveries of possible major importance to which they referred are a producing well off Terrebonne Parish, La., of Kerr-McGee Oil Industries, Inc., and one drilled by the Humble Company off Jefferson Parish, La.

The first is a very shallow well, producing from a super-cap sand through perforations about 1,750 feet deep. The Humble discovery came at a depth of about 8,650 feet in a second well drilled in the area. Until other wells are drilled, no proper evaluation can be made of the discovery, but the prospect is promising.

As generally understood, a continental shelf is the land mass lying submerged off the coast in less than some 600 feet of water. The United States continental shelf covers 750,000 square miles, of which 129,000 are in the Gulf of Mexico. This strip averages about 75 miles in width. It is in this Gulf shelf that oil men expect to find the best oil reserves.—*Science News Letter*, November 20, 1948.

Florida State Road Department Re-Mapping Program

By JON S. BEAZLEY

PHOTOGRAMMETRIC ENGINEER, STATE ROAD DEPARTMENT OF FLORIDA

THE State Road Department of Florida recently began the momentous job of mapping the entire State of Florida, county by county. These maps will be to the scale of 1 inch equals 1 mile, with lithographic reproductions at 1 inch equals 2 miles. The primary purpose of the maps is for road studies and future planning; therefore, first emphasis is placed on the classification and true location of all public roads.

In addition to roads, the black and white planimetric maps will show hydrography, railroads, all rural homes and other buildings such as churches, schools, stores, sawmills, lighthouses, mines, post offices, etc., communities, airfields, government lands, and corporate limits. Also to be included will be township and section numbers, plane coordinate and geographic ticks, magnetic declination, and survey control monuments. Where space is available, an attempt will be made to include abandoned logging railroads, historical and scenic sights, navigation markers, swamps, etc.

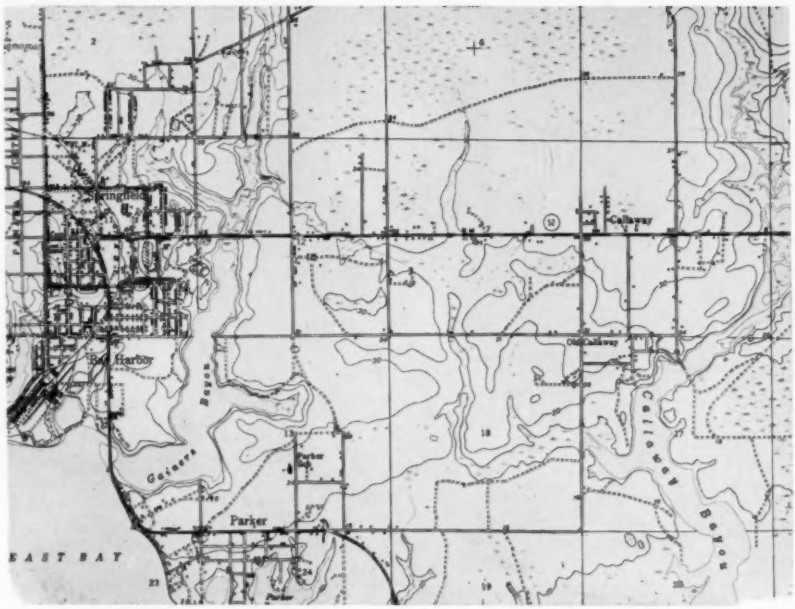
This program, sponsored jointly by the Public Roads Administration, Federal Works Agency, and the State Road Department of Florida, is being conducted under the direction of W. M. Parker, Division Engineer, Division of Research and Records, State Road Department of Florida. The symbols and standard mapping accuracy of this work comply with those established by the Public Roads Administration for all maps of this classification.

Although officially these maps are revisions of the existing State highway and transportation maps, actually the new maps are being compiled with few references to the former. Whereas the existing maps were hastily prepared, under adverse conditions, the new editions are being compiled by using the most modern and up-to-date methods known to the surveying and mapping profession.

Before World War II few people other than cartographers realized the deplorable scarcity of accurate maps both in the United States and the remainder of the world. This condition was mentioned in a recent issue of *Newsweek*, ". . . less than 5 percent of the world's land has been mapped in accurate detail." Also, ". . . even after 141 years of surveying, only half the land of the United States is mapped. Least mapped States include Florida, Georgia, Mississippi, Montana, Oklahoma, South Dakota and Texas; the most accurately mapped section is New England." In this news story, reference is made to maps scaled 1 inch to the mile, or larger, which contain contours showing the vertical shape of the earth as well as the horizontal. This type is designated by the name "topographic or contour map" (fig. 1).

Philip Gustafson's article, "Columbus Would be Disgusted," in *Nation's Business*, May 1947 quotes the Chief Geologist of a Texas oil corporation in part: "It's a national

Reprinted through the courtesy of *Florida Highways*, June 1948.



Public Roads Administration

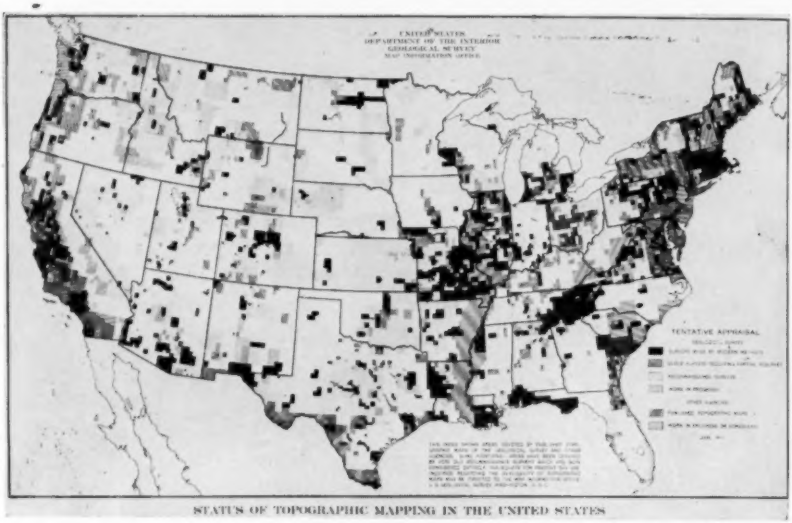
FIGURE 1.—U. S. GEOLOGICAL SURVEY TOPOGRAPHIC MAP NEAR PANAMA CITY, FLA. This illustration shows a part of a map containing nearly all of the essential features desired by map users, among which are contour lines.

scandal that the United States, richest nation in the world, is not yet mapped topographically, 170 years after its foundation. Oil finding deals largely with topography. Yet, in a particular area of Texas, one of the greatest oil-producing provinces in the world, not one accurate topographic map has been made since oil was discovered here in 1920."

According to a map published by the Map Information Office, Texas appears to be much better mapped than Florida (fig. 2). As another example for the need of maps, Mr. Gustafson also cites in the same article: ". . . the Winston-Salem industrial area in North Carolina lost $10,000,000 worth of new industries when it could not provide adequate maps to give prospective manufacturers the facts about new sites they were considering."

COST OF NEW MAPS SHARED BY STATE AND FEDERAL DEPARTMENTS

Mapping of this high degree of accuracy and completeness, referred to in the above article, is prohibitively expensive unless the cost is shared by several agencies. The mapping program now being conducted in Florida is a less ambitious undertaking, for it does not attempt to approach the standards met by the above maps. However, until sufficient funds are appropriated for the making of these very desirable and essential maps, the ones now being made will be of unlimited value.



U. S. Geological Survey

FIGURE 2.—Status of Topographic Mapping in the United States, January 1947.

These mapping differences can be illustrated by a comparison with automobiles. The large scale maps mentioned in *Newsweek* and *Nation's Business* are comparable to today's finest automobiles. The maps being compiled by the State Road Department of Florida are equal to today's popular priced cars and the existing maps compare with the cars in vogue in the 20's. Incidentally, due largely to methods advanced during the war, cartography within the past ten years has advanced more rapidly than the products of the automotive industry.

But let us return to maps. Since the inventory of Florida's resources is so vaguely recorded in map form, every effort is being made in the present program to lay the groundwork for better maps of the future. This is possible because modern methods are being used. This modernization has made cartography faster, more accurate, and far less expensive than formerly.

The topographic engineer (fig. 3), often recognized by his boots, battered hat, and unlit pipe, has changed to office clothes and now applies the latest principles set forth by scientists of the

Public Roads Administration

FIGURE 3.—TOPOGRAPHIC SURVEY PARTY. The umbrella is to protect the surveying instrument. Extreme heat or sudden changes in temperature will seriously affect the instrument's accuracy.

cartographic profession. Today he spends almost all of his time in a comfortable office compiling and drafting the many lines and symbols into patterns that comprise a map. Where yesterday the map maker or the surveyor lugged his surveying instruments through snake-infested swamps and scrubland thick with sand flies, now he secures almost all of the necessary mapping information from aerial photographs.

Aerial photographic coverage of Florida was made available only recently (fig. 4). But even now much more data are essential in the preparation of a map. Contrary to a general belief, aerial photographs are *not* maps. They are a means of making a map.

The development of the other elements considered prime factors in mapping has had a slow but interesting progress. Long before Florida was sectionized by ranges and townships, rulers of the Old World bestowed favors on a selected few subjects by granting them title to various parcels of land in America. Quite a number of these land grants are located along the eastern coast of Florida. Many early settlers, traders, explorers, and others attempted to show on paper the territory of Florida. The resulting maps were elegantly drawn and depicted shore lines, harbors, forts, and scattered settlements, but often, because of indifference, ignorance or lack of proper instruments, prominent land marks were omitted in favor of features serving no purpose except to display the draftsman's skill (fig. 5).

Department of the Air Force

FIGURE 4.—FAIRCHILD K-17 AERIAL CAMERA.

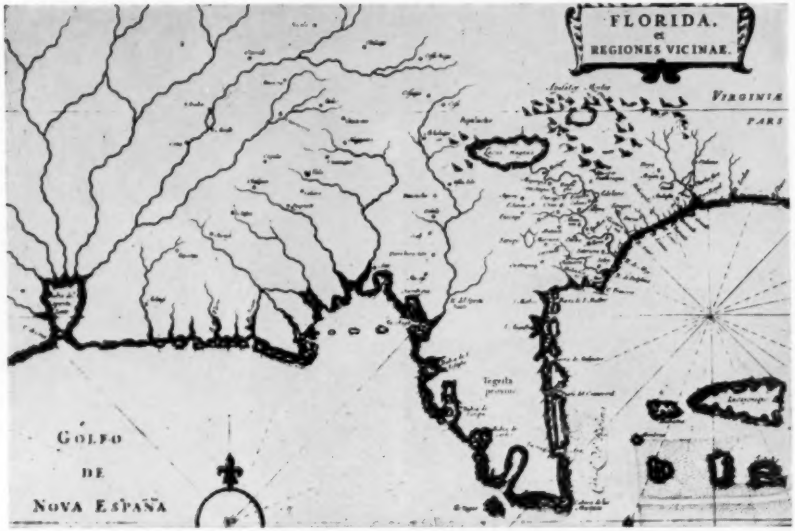
This camera, which holds a roll of film 10 inches wide and more than 200 feet long, takes a photograph sharp enough to show a highway center line strip from an altitude of two miles.

Later English and American surveyors redrafted the features of Florida with increasing accuracy in showing its true shape. These maps indicated little other than navigating aids. In the early eighteen hundreds the United States General Land Office (now the Bureau of Land Management) established offices in Tallahassee and from there directed the first attempt to survey the entire State.

First, they divided the land into blocks, measuring 6 miles square, such blocks being known as townships. The townships were then subdivided into 36 blocks, 1 mile square, these being called sections. From east to west the townships were divided by range lines, also 6 miles apart. In the north and south directions the divisions are known as township lines.

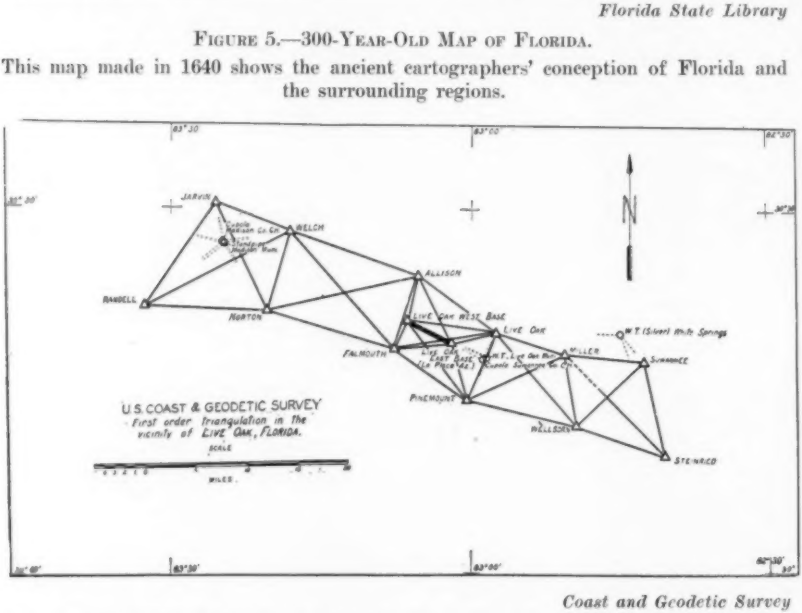
ORIGIN OF BASE LINES IN TALLAHASSEE FOR STATE-WIDE CONTROL

To accomplish such a huge undertaking, base lines originating in Tallahassee, were first established. Then the survey parties branched out over the State to locate and subdivide the townships. Because of the varying mag-



Florida State Library

FIGURE 5.—300-YEAR-OLD MAP OF FLORIDA.
This map made in 1640 shows the ancient cartographers' conception of Florida and the surrounding regions.



Coast and Geodetic Survey

FIGURE 6.—An Arc of first-order triangulation in Florida. Heavy line shows the accurately measured base line. Nearly the entire state of Florida is covered by such precise triangulation surveys.

netic attraction of their compasses and errors in turning angles and measurements, joining surveys often resulted in "jogs" or mismatches. The odd-shaped lots resulting are sometimes known as hiatuses.

Not long after the sectionalization was completed, others became active in surveying and mapping in Florida. In order to show accurately all desired features on coastal navigation charts, the U. S. Coast and Geodetic Survey has established many triangulation and line surveys throughout the State (figs. 6 and 7). Those surveys were necessary primarily as control for the mapping of the Florida coastlines but serve also as a framework for surveys by other agencies.

The resulting surveys exist on the ground as triangulation or survey monuments in hundreds of brass identification plates anchored in concrete posts (fig. 8), and are also recorded in tabulated form. These records, available from the Coast and Geodetic Survey, show the position on the earth's surface of each monument. The accuracy of the location of these monuments has been determined and recorded to the fraction of a foot. These positions are located in reference to the Greenwich (England) Meridian and the Equator, and also to a system of square coordinate lines (plane coordinates) computed especially for map making in Florida.

Coast and Geodetic Survey

FIGURE 7.—ERECTING A BILBY TRIANGULATION TOWER.

This steel portable triangulation tower is one of many in use by the field parties engaged in geodetic surveys. These towers consist of two tripod structures; the inner structure serves to support the theodolite and the outer structure, independent of the other so as not to disturb the instrument, is for the observer and recorder, or lightkeeper.

THREE SYSTEMS OF PLANE COORDINATES USED

Because of Florida's shape it was necessary to compute three kinds of plane coordinates in order to show the least distortion on any desired map. Maps of the north and northwest part of the State are most accurately compiled by using the North Zone Plane Coordinates on the Lambert projection. For the eastern half of the State (east zone) plane coordinates are used on the transverse Mercator projection; plane coordinates for the west zone are also used on the transverse Mercator projection.

In addition to surveys by the Bureau of Land Management and the Coast

Coast and Geodetic Survey

FIGURE 8.—SURVEY MARKER SET IN CONCRETE.

To preserve the survey points in the national control network, stations are marked with a bronze disc set in a concrete slab which extends about 3 feet in the ground.

and Geodetic Survey, the U. S. Geological Survey and the Army Corps of Engineers have made large-scale topographic maps in the northwest and west central areas and in the Florida Keys. The U. S. Soil Conservation Service has mapped various areas in the State, the most prominent being the Everglades Drainage District. These maps place emphasis on soil types.

During the early days of the Roosevelt Administration quite an intensive surveying program was conducted throughout the State under the direction of B. R. VanLeer, Florida Mapping Director, in co-operation with the Coast and Geodetic Survey and other Federal Agencies.

The Public Works Administration published in book form the data from these surveys that comprise the North Zone of the Plane Coordinate System. Lack of funds stopped this work before it was completed. At the present time field notes of the east and west zones are being examined and compiled by the Engineering School of the University of Florida with a view toward publication.

In addition, highway, railroad, and canal surveys have criss-crossed the State many times with ties to section lines, control survey monuments, and other permanent features. Often these surveys are of an accuracy acceptable to cartography.

AERIAL PHOTOGRAPHS NOW COVER ENTIRE STATE

Within the last decade the U. S. Department of Agriculture let contracts for the aerial photographing of areas comprising 52 counties of Florida for their farm crop measurement programs. This photography is available to the public at the cost of reproduction, which is a fraction of its original cost. Supplemental aerial photography by other agencies, such as the Corps of Engineers and the Air Force gives coverage for nearly the entire State.

It would appear, after considering all the time, effort, and funds devoted to mapping in Florida, that we should have complete and accurate maps for all our needs. Had those investments in mapping been expended in a coordinated, complete mapping program, we would have the desired maps. Unfortunately, each mapping agency had a limited purpose and produced maps to serve that purpose. As a result, we have few accurate maps suitable for a general purpose or for all purposes.

The Hayden-Cartwright Act of June 18, 1934 and subsequent authorization of Federal-aid appropriations, earmarked 1-½ percent of the funds apportioned "for surveys, plans and engineering investigations of projects for

future construction. . ." Under that provision of the law, there have been organized in all of the States "Statewide Highway Planning Surveys" which operate as Federal-aid projects under joint supervision of the respective State highway departments and the Public Roads Administration, with general uniform practices and procedures.

STATE-WIDE HIGHWAY PLANNING SURVEYS

A basic activity of these highway planning surveys has been the taking of an inventory of every mile of public road in each state with all pertinent data of interest in highway planning studies. This information and other pertinent data are shown on strip maps and planimetric county maps prepared to the scale of 1 inch equals 1 mile. Because the war seriously curtailed work of this nature, only minor revisions of the Florida maps have been made since the originals were completed in 1936.

The present mapping schedule is for 10 maps per year, showing features to an accuracy that will locate them within the area covered by the symbols. In addition to information necessary for road studies and future planning, additional data desired by others will be included, provided it does not interfere with the basic requirements.

Many Government agencies and private organizations have been most generous in supplying information for the preparation of these maps. An attempt is being made to secure and classify copies of all existing maps and photographs of the State. All maps received are carefully examined and cross-checked for correct names, spelling, and other useful data. Special emphasis is placed upon the true location of section and land grant lines. This additional information, together with aerial photographs and survey control, forms a basis for highly accurate and amazingly economical maps.

THE COUNTY IS BASIC UNIT FOR MAPPING PURPOSES

Prior to mapping a county, complete aerial photographic coverage is purchased. All existing maps, charts, survey notes, and Bureau of Land Management plats are examined for completeness, accuracy, etc. Next, the photography and other data are sent to the Division's Project Engineer stationed in each of the Road Department Division Offices. This engineer, using the control survey and allied data as a guide, visits a specified number of monuments and locates the exact positions of these points on the aerial photographs. Also, he locates on the photograph two or more widely-separated section corners of each township.

When sufficiently annotated, these aerial pictures are returned to Tallahassee. Since these photographs have stereoscopic overlap, every ground feature appears on a minimum of two photographs, and sometimes on as many as six photographs. The first office job is to transfer all control points to each photograph on which the points show. A map projection to the scale of the photography is laid on a large table made especially for this purpose. The survey points are accurately plotted on the board.

Next, points such as road crossings, fence corners, buildings, etc., that appear on three or more photographs are located and identified by colored circles. Thus, by the intersection and resection of rays from the nadir or plumb points (a position on the ground directly under the camera at time of exposure) of the photograph, these identification and ground survey points are linked directly to the earth's sur-

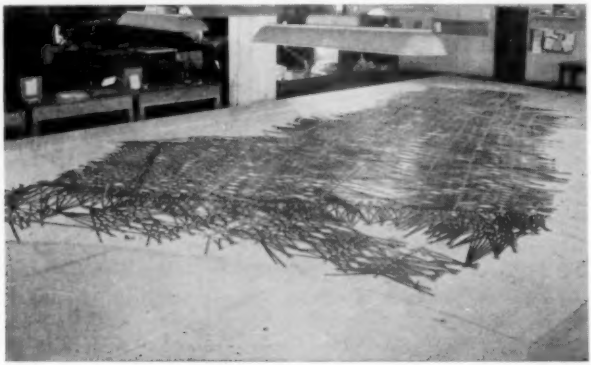
face. With these points serving as the framework, all of the photographs are tied together by a graphic application of a mathematical process called radial line plot. This is somewhat like making a patch quilt (fig. 9).

After all templates representing the aerial photographs have been joined together to the satisfaction of the photogrammetrist, pins are driven through the points of resection of these rays. This locates on the projection board the easily identified photo points at their true geographic positions. At this stage of the map every photograph has at least eight identifiable points appearing on a projection of known dimensions and scale.

While the radial line plot was being laid, other draftsmen were busy delineating the photographs. This work, although at times tedious and exhausting, is of the utmost importance.

Pairs of photographs are next placed in a mapping stereoscope and by referring to all existing maps the operator identifies streams, churches, communities, etc., which are marked with colored grease pencils directly on the photographs. Firebreaks, fence lines, roads, and ditches are carefully examined for possible indications that they might be section lines. If they form a logical pattern, agreeing with points identified during the field inspection, ticks are marked at points considered section corners. While viewing the photographs in the third dimension, the operator marks all visible rural buildings, drainage, and heavy stands of timber.

After the radial plot is complete the many photograph points are transferred to map manuscript sheets. Next, the delineated photographs are placed in a photographic mapping instrument known as the Sketchmaster (fig. 10). This instrument enables the operator to see simultaneously the map sheet and the photograph. By adjustment of the Sketchmaster the photograph identification points are superimposed directly on to their corresponding points on the manuscript. The draftsman now draws all desired features accurately on the manuscript.



Public Roads Administration

FIGURE 9.—METAL TEMPLATE RADIAL ARM PLOT.

Metal templates representing rays from photo centers are linked together by their intersection at points common to several photos. These templates are tied to control points previously plotted on the projection board.

Public Roads Administration

FIGURE 10.—USING A VERTICAL SKETCHMASTER.
By the use of a half silvered mirror the operator sees the photo image projected on the table. This enables him to trace all desired photo detail on the map manuscript.

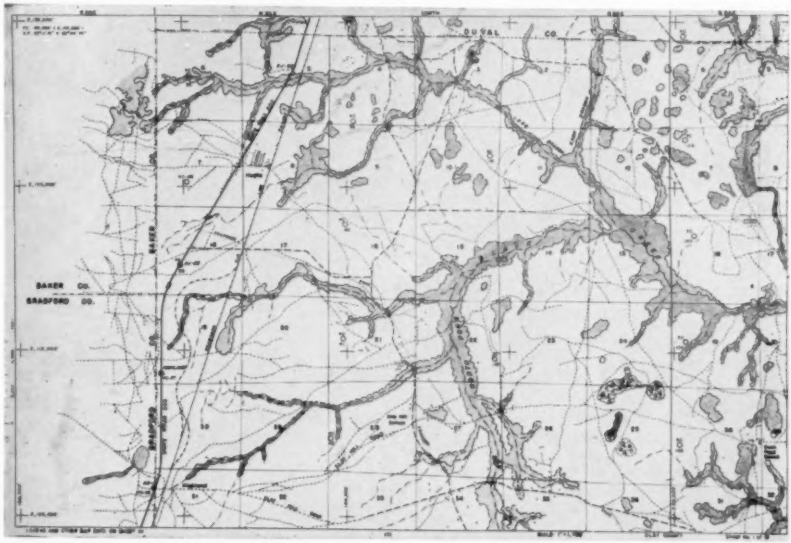


FIGURE 11.—This typical map manuscript, one of nineteen necessary to map Clay County, Florida, was prepared from aerial photographs and other data. Used in conjunction with the photographs these maps are of unlimited value for road location, computing drainage areas, malaria control, estimating timber, tax assessing, property ownership, geological surveys, etc.

When all manuscripts for a county have been completed and office edited, they are sent to the Project Engineer who makes a completion survey and field edit (fig. 11). This includes examining the manuscripts for omissions, errors and discrepancies. While doing this he also travels all roads and records on an inventory form the mileage, classification, condition of the roads, also pertinent data on bridges and buildings. When the field work is completed, corrections are made on the manuscript and then the final map is drafted to the scale of 1 inch to 1 mile. Again the map is edited. After this final inspection, positive transparencies at scale and lithographic reductions at half scale are made for reproduction and distribution.

Maps of Wakulla, Franklin, and Gulf Counties have been completed and are at the present time being made into tracings for reproduction. Work is now in progress on maps of Bay, Brevard, Broward, Clay, Dade, Duval, Flagler, Hillsborough, Nassau, Palm Beach and Pinellas Counties.

❦ ❦ ❦

A New Tool For Surveying

Surveyors of the Dominion Geodetic Service, working in the Teslin Lake area in British Columbia, this summer will have a new tool to help them overcome the old problem of reaching difficult points where Geodetic stations must be established. The new tool—a Bell Helicopter.

Kenting Aviation Ltd., aircraft operating company for Photographic Survey Co. Ltd., Toronto, announced May 31st, that its Bell helicopter and crew, along with a 5 ton truck, which will be used as a mobile hanger and machine shop, have been leased by the Dominion Government and are en route by rail to Dawson Creek, B. C. Seven hundred miles to the northwest, the aircraft will begin a four months' period of transporting surveyors of the Dominion Geodetic Service to selected positions very difficult to reach on the ground, for the purpose of establishing geodetic stations and control points. The new technique is expected to speed up the progress of this vital work materially compared to that previously possible.

The area in which the helicopter will be working this summer has never been adequately mapped, partly due to difficult terrain. The stations set up will be part of the regular geodetic network, which is essential for the control of topographic mapping and geological investigations, so necessary for the development of Canada's material resources.

The first step will be to transport and land surveyors by helicopter to select suitable high points for the triangulation stations. Men will then be flown in to mark and prepare these points for subsequent observations and finally observers and lightkeepers will be set down at these points to make the precise angular measurements from each station.—*The Canadian Surveyor,* July 1948.

Qualifications of a Land Surveyor

By F. N. HOLMQUIST
CIVIL ENGINEER, PHOENIX, ARIZONA

EDITOR'S NOTE.—This article by Mr. Holmquist, together with the two articles immediately following all treat generally the same subject. The three articles are therefore arranged together to form a sort of symposium on the general subjects of property surveying versus engineering surveying, and qualifications for each.

IT IS NOT a simple matter to answer the question "What are the qualifications of a land surveyor?" Perhaps the matter can best be presented by considering some of the problems which confront land surveyors, then suggesting the qualifications which are necessary to solve these problems so as to get the right answers.

At the outset it should be stated that a surveyor is not an advocate. The surveyor must give to the client only that which is rightfully his and must leave for the other fellow all that is rightfully his. Where boundaries or ownerships are completely uncertain, the surveyor may then legitimately, of course, give the client the benefit of the doubt. But in such cases the surveyor should always be honest and frank with the client, advising him fully as to the doubts and uncertainties, and the reasons therefor. Obviously this will avoid bitterness and reproach later if a court should decide the other way.

Many civil engineers, and a substantial number of laymen, seem to have the impression that almost anybody can quickly become qualified to do land surveying. It frequently happens, for example, that civil engineers who have full-time jobs at other kinds of engineering work, undertake to do odd jobs of land surveying on their personal time in evenings, holidays, and week-ends, either to make extra money, or to accommodate friends who do not want to pay regular prices for property surveys. Because many civil engineers are not fully qualified to make the proper decisions in doubtful boundary and ownership cases, the results of these side-line surveys often are erroneous. This usually causes trouble and confusion for the original client as well as adjoining land owners. And of course such situations tend to discredit both civil engineers and land surveyors in that locality. It is strongly urged that civil engineers who are not qualified land surveyors abandon the practice of doing odd jobs of property surveys in their overtime hours.

Why does the civil engineer consider himself to be qualified as a land surveyor? After all, in most engineering schools the entire surveying course extends over only one or two years, and usually only a week or two of this time is devoted to the principles of property surveying. Obviously even the brightest student cannot in that short time learn enough to qualify as an authority on the determination of doubtful boundaries. The civil engineering education gives reasonably thorough instruction in the use of surveying instruments, in methods of measuring, and in the mathematics required for computing and adjusting the survey measurements. But engineering schools ordinarily do not attempt to prepare the student for duty as a researcher in old property records, or to be an authority on property-title laws.

A professional land surveyor must be qualified to make surveys and boundary decisions that will stand up in court. Thus he requires not only a knowledge

of the use of surveying instruments, measuring procedures, and mathematics, as taught for engineering activities, but also a thorough knowledge of the laws, rules, and regulations involved in boundary questions. In addition, he must have a thorough knowledge of the property-boundary peculiarities for the area in which he is operating. These qualifications cannot be acquired overnight, or even in a few weeks of intensive surveying training in college.

The qualification of detailed knowledge of peculiar local conditions is particularly important. Obviously the longer a land surveyor practices in one locality the better qualified he becomes, so far as that locality is concerned. In order to become increasingly more proficient in any locality it is necessary, for obvious reasons, that the surveyor maintain a cumulative file of detailed records of all surveys made and data as to the locations of corners found or established. Such records must be properly filed and indexed and kept in good order, otherwise they are worthless. This requires the qualifications of diligence and industry.

The ability to find and identify corners is a qualification of prime importance in a surveyor. This ability is partly natural and partly acquired. A good surveyor develops an instinct for finding corners, and it has been said of some surveyors that they can smell a corner. A great deal of trouble has been caused by surveyors (including General Land Office surveyors) setting new corners where old, established corners were already in place, thereby making double corners.

The object of a resurvey, generally speaking, is to restore corners to their original positions, which frequently are not the same as the positions which would be determined by remeasuring and prorating differences. In setting permanent survey monuments and compiling maps of areas annexed to the city of Phoenix, certain of the city's engineers have taken it upon themselves to "correct" what they considered errors in the original surveys of the various subdivisions involved. Such practice leads to serious confusion. As a result, a property owner who has built a fence or even a brick wall conforming exactly with the original lot stakes may find that, according to the city's resurvey, he is encroaching on his neighbor. Also as a result, he may be threatened with a law suit, or the alternative of "buying" a sliver of ground which he in fact already owns, at a price fixed by the "seller." All land surveyors should know, although some apparently do not, that they do not have the right to restore corners by arbitrary methods. The methods of restoring lost or obliterated corners are well defined by laws and rules and regulations, all of which should be meticulously observed.

In cases in which an obliterated corner can best be restored from collateral evidence, such as fences or other improvements, it is unlikely that two or more surveyors would restore the corner at exactly the same point. When restorations are made in this manner a careful search and investigation should be made to determine if some other surveyor has not already restored it. In the author's experience he has found as many as three or four iron pipes within a few inches of each other, and a few inches below the surface of the ground, all purporting to mark the same corner. A little diligence, industry, and common sense on the part of surveyors would avoid such situations.

A land surveyor should not be satisfied with a job of surveying until he has checked and proved his work, and knows it to be correct. Whenever he makes

a survey he is figuratively "on the spot," and may have to defend his work in court. He should, therefore, have a serious attitude toward his work and be willing and able to stand behind it. A person who takes the attitude that his work is of little importance, and that mistakes can be laughed off, is unfit to be a land surveyor, regardless of his other qualifications.

The work of subdividing land naturally falls to the land surveyor, and in growing communities such as Arizona a great deal of subdivision work is currently being done. These subdivisions will be in existence a long time, and the surveyor should appreciate the importance of the work he is doing, and do it right. Otherwise he is laying the foundation for never-ending strife, and is definitely impairing the value of the property.

Another qualification of prime importance in a surveyor is courage. Frequently a surveyor's client, or some person who owns land adjoining, attempts to influence the surveyor to do incorrect work for the purpose of gaining land at the expense of the adjoining owner. Such attempts may take the form of flattery, bribery, threats, or a pretended knowledge of where a corner or line belongs. An experienced surveyor usually knows how to handle such situations, but firmness and courage are essential in dealing with such people. A surveyor does not serve his client's best interest by trying to give him land that does not belong to him. The surveyor must be meticulous to claim for the client exactly all that does belong to him, but no more and no less.

Frequently it happens that the records of titles are in poor shape, and some times deeds conflict. In such cases a court decision may be necessary to determine who is the real owner. A knowledge of the law involved and a judicial mind are of great value in such cases. When courts are called on to fix the boundary line between two tracts of land they usually have to choose between one of two or more surveys. Other things being equal, the surveyor who has made the most exhaustive study, and has without bias considered the merits of all the surveys and records presented, naturally has the advantage. In cases of litigation over disputed surveys, the surveyors interested should attempt to come to an agreement before the case is tried. If one of the surveyors lacked knowledge of pertinent facts known to the other, and thereby made an erroneous survey, he should admit his error and correct his survey. He may therewith save himself and his client the cost and humiliation of losing a law suit. Common sense should dictate such action, and common sense is essential to do good property surveying.

Land surveying is a learned, honorable and dignified profession but, unfortunately, many surveyors have an inferiority complex and talk about it in an apologetic manner, as though it were not on a par with other professions. This attitude of inferiority makes it difficult to charge and collect reasonable fees for surveying work. When the pay is inadequate the surveyor is more likely to be inclined to sacrifice quality and do a poor job of surveying. A practicing surveyor should always do good work, and to be able always to do good work he must charge fees that will yield him a reasonable return. The amount of work he does and his charge therefor should not be influenced by any preconceived ideas of his clients as to how long it will take to do the job, or what it should cost. Frequently persons who inquire about a survey job state that it will take only an hour or two when, in fact, it might require two or three days, or even a week. It requires tact and courage to convince a layman who thinks

a job should be done for twenty dollars, that two hundred dollars would be a reasonable price. But if two hundred dollars *is* a reasonable price, it is best to look him in the eye and plainly but tactfully tell him so.

To sum up, a surveyor should have a thorough knowledge of surveying instruments and procedures, and of the required mathematics. He must also be entirely informed regarding all the numerous laws, rules, regulations, and precedents involved in property boundary questions. He should be careful and accurate in his work, and have a serious attitude toward it. He should have the ability to find and identify corners and other landmarks. He should be firm, courageous, and absolutely honest. Since his work is subject to review by the courts, he should attempt to consider doubtful matters as a judge rather than as an advocate and should therefore attempt to develop a judicial mind. And last, but not least, he should be blessed with common sense.

Land Surveying Versus Engineering Surveying

By GEORGE D. HENNING
REGISTERED LAND SURVEYOR, ROSCOMMON, MICHIGAN

MUCH HAS BEEN SAID about the overlapping functions of the land surveyor and the civil engineer, and occasionally there have been charges of abuse and malpractice by each group against the other. It becomes apparent that a proper analysis of "surveying" has not been well thought out by many of those who have undertaken to discuss the subject. It is the purpose of this discussion to attempt to make such analysis, and to define the functions of the land surveyor and the civil engineer with respect to surveying.

Both the surveyor and the engineer must necessarily be skilled in the use of surveying instruments. They both must know the proper procedures for running lines and curves, measuring angles and distances, and making plats and maps of such surveys. Also, they both must have proper knowledge of the mathematics involved in surveying operations. Assuming each to be competent to perform these tasks consistent with present-day practices, there is little difference between the two professions with respect to ability to obtain the required degree of accuracy in the instrumental and mathematical operations. However, there are other differences which are significant.

The surveys necessary in connection with civil engineering activities are primarily to procure data and information incidental to planning, designing, and laying out a project or works. The part of such surveys relating to boundary-line determination and land ownership is usually regarded by engineers as important only so far as it affects rights-of-way or the limits of the project. The engineer's attitude toward the property survey on works projects is frequently that of "getting by and staying out of trouble."

Probably any competent civil engineer could properly execute an independent property survey, such as original township and square-mile section sub-

divisions by the United States General Land Office (now the Bureau of Land Management) surveyors in unsurveyed territory, by application of the surveying principles and practices which he learned as part of his civil engineering education. This is because independent property surveys do not require the exercise of judgment based on extensive knowledge of property-title law. Rather, engineering knowledge of surveying techniques is the prime requisite. However, in present-day practice the need for independent land surveys occurs only occasionally. In most states independent property surveys are confined mainly to rather small areas where, after dependent surveys are made to determine the limits of tract ownership, independent subdivisions of a tract are required.

The surveys necessary in connection with property-boundary work are primarily to gain information incidental to arriving at decisions as to the respective rights and equities of adjacent land owners. This includes the important task of correlating on-the-ground conditions with official land-ownership records. Later the boundary-line and property-corner decisions must be marked out on the ground, appropriate final measurements and computations made, and plats or other forms of official records prepared. In those states covered by the government's public-land surveys, all land titles were originally founded on the General Land Office subdivision surveys and the United States Patent, and are subsequently founded upon the subsequent conveyances of title and the subsequent surveys made to be consistent with the title. In these areas the land surveyor's field investigations and studies may be complicated by such factors as the inaccuracies of some or all of the preceding surveys, the inconsistencies of preceding conveyances of all or parts of the tracts, the incompleteness or vagueness of the tract descriptions involved, equities which may have been established through adversity, corners and lines of long acceptance but without substantiation by record, and by numerous other conditions which may be found both on the ground and in the records. Similar conditions may also be encountered, of course, in some of the unsubdivided states.

The primary responsibility of the land surveyor, then, is to gather all the pertinent facts obtainable, both from the new field surveys and from the records of title transfers and previous surveys; to carefully weigh all such facts, one against the other; and finally, to apply the judicious reasoning which will lead him to sound conclusions and which would satisfy the courts as to the respective interests and equities of all the affected interests, whether or not the courts are actually called upon to rule in the matter. This places a serious responsibility on the surveyor's knowledge of the laws and court rulings in such matters, as well as on his capacity for thorough research and sound reasoning. To repeat for emphasis, the field surveys are only incidental to the land surveyor's objective.

Thus, it is demonstrated that the civil engineer and the land surveyor are equally competent to perform the field surveys and the mathematics necessary for obtaining the data which each needs to accomplish his objective. It is also apparent, however, that the attitudes and objectives often may be very far apart. Thus, it seems clearly indicated that the land surveyor should make all the decisions regarding land corners and boundary lines in accordance with Federal, State, and local laws, court rulings, and other regulations. Likewise, it is clearly the function of the civil engineer to make such surveys as are necessary to supply him with data to plan, design, construct, and complete any engineering project.

There are no infringements or overlapping of functions between the two, even if the civil engineer employs the land surveyor to do the field surveying he required, or vice versa. In either case each decides what information is needed, for what purposes and how it is to be used, and what instruments and methods are appropriate. Many in the ranks of both civil engineers and land surveyors have not been able to understand these distinctions between their respective fields or functions. This lack of understanding has undoubtedly resulted in much confusion.

Surveying is an ancient art, and for ages was considered in the same field of activity as civil engineering. The complexities of modern civilization have generated many special phases of civil engineering endeavor. Several of these specialties have come to be generally recognized as separate professions—land surveying being one of these. The legislatures of those states having Registration Acts under which professional engineers are registered in one category and land surveyors in another, in effect have recognized that land surveying is a distinctly separate line of endeavor or profession, and in effect have legally established it as a separate profession under the jurisdiction of the Act.* Applicants for registration as land surveyors in these states usually are required to take separate and different examinations from engineers. However, it appears that the examinations usually given to land surveyors do not thoroughly explore and establish the applicants' qualifications for the functions they are expected to perform. This probably is due to lack of co-operation with the State Examining Boards by the land surveying profession. So long as schools have no regular course in this subject, however, it remains difficult to set up a proper examination for it.

In that connection, it has been frequently charged that engineering schools do not teach land surveying. Before such can be argued, it is necessary that the term "land surveying" be defined. If land surveying is defined, as above, to include the professional-judgment functions which a surveyor must perform to fulfill his proper place in his community and field of operation, then it is quite clear that the engineering schools do not prepare students for this particular field. If it is defined as being only the knowledge of instruments, measurements, and mathematics, the schools do teach it as it is necessary to the civil engineering education.

In order that land surveying may be increasingly recognized as a professional field, and for other pertinent reasons, it is desirable that the "Technical Standards for Property Surveys," as adopted and published by the American Congress on Surveying and Mapping (*see* SURVEYING AND MAPPING, July-Sept. 1946), be followed by all land surveyors. The published pamphlet on this subject contains also a well-written and pertinent article by Mr. Wm. C. Wattles, dealing with the functions of private-practice surveyors, which should be read by every practicing land surveyor.

* See article following.

Report of Committee on Land Surveying

National Council of State Boards of Engineering Examiners

1. *Definition of land surveying.*

It is the opinion of this committee that the profession of land surveying comprises the determination of the location of land boundaries and land boundary corners; the preparation of maps showing the shapes and areas of tracts of land into smaller tracts, including the layout of roads and streets, and rights of way of same, to give access to smaller tracts; and the preparation of official plats or maps of said land subdivisions, in compliance with the laws of the states in which the work is done.

The profession of land surveying also includes the preparation and interpretation of land descriptions for incorporation in deeds, leases and other legal documents, and the application and interpretation of U. S. General Land Office (now the Bureau of Land Management) and court decisions, as such decisions relate to original surveys and resurveys.

Land surveying does not include engineering surveys, such as those required for the planning and construction of railroads, highways, airports, utility lines and bridges, although the determination of the boundaries of the lands to be used for such engineering construction and the preparation of the legal descriptions of same is land surveying and not engineering surveying.

The surveying necessary for the preparation of a topographic map is engineering surveying and not land surveying.

2. *Educational requirements for registration as a land surveyor.*

An applicant for registration as a land surveyor should have a thorough knowledge of, and pass, or be able to pass, examination in the following subjects:

(*a*) Fundamental mathematics, including algebra, geometry, trigonometry, and logarithms, and the application of said fundamental mathematics to survey problems including the closing of surveys; the calculation of coordinates or latitudes and departures; and the use of coordinate systems in the control of surveys.

(*b*) The use of surveying instruments and their adjustments with particular emphasis on the causes of angular errors and errors in chaining.

(*c*) The history and principles of the systems of land subdivision in use in the state in which he is applying for registration, and knowledge of the U. S. System of Public Land Surveys, and preparation of neat and legible plats.

(*d*) The instructions of the U. S. General Land Office relative to the relocation of lost and obliterated corners and the subdivision of sections, if he is applying for registration in a state using the U. S. System of Public Land Surveys.

(*e*) The legal essentials of surveys and resurveys, including those involving disputed boundaries, defective descriptions, riparian rights, and adverse possession.

(*f*) The judicial functions of land surveyors.

(*g*) Those laws of the state which pertain to the conveyancing and subdivi-

sion of land and particularly to the filing of official plats and maps which become parts of the public records.

(*h*) The preparation of land descriptions for incorporation in deeds, leases, and other legal documents, and interpretation of land descriptions prepared by other persons.

3. *Types of work which may be performed by registered land surveyors, and registered engineers who are not registered land surveyors.*

(*a*) A registered land surveyor may make engineering surveys incidental to his work as a land surveyor, provided he does not attempt to express opinions on engineering matters in connection with said surveys, and does not prepare engineering reports or prepare designs for engineering construction work.

(*b*) A registered engineer who is not a registered land surveyor may make land surveys incidental to his work as an engineer, provided he does not attempt to establish boundary lines; and provided he does not attempt to make plats of record; and provided he does not attempt to qualify as an expert witness on land survey questions.

▼ ▼ ▼

Splitting the Infinitive

(This is reprinted in its entirety from the *Chemical Digest* of Foster D. Snell, Inc., who admitted that it was written by some author whose name could not be ascertained.)

One of the most closely guarded secrets of the era can now be told, how an anonymous group of grammarians, working in secrecy in a remote section of the country, have finally succeeded in splitting the infinitive.

The so-called "Bronx Project" got under way in 1943, with the installation of a huge infinitron specially constructed for the job by Cal Tech philologists. Though the exact details are still withheld for reasons of security, it is possible to describe the general process.

From a stockpile of fissionable gerunds, encased in leaden cliches to prevent radioactivity, a suitable subject is withdrawn and placed in the infinitron together with a small amount of syntax. All this material must be handled with great care as the slightest slip may lead to a painful solecism. Once inside the apparatus, the gerund is whirled about at a great speed, meanwhile being bombarded by small particles. A man with a Gender Counter stands always ready to warn the others if the Alpha-Betical rays are released in such high quantities as to render the scientists neuter.

The effect of the bombardment is to dissociate the whirling parts of speech from one another until at length an infinitive splits off from its gerund and is ejected from the machine. It is picked up gingerly with a pair of hanging clauses and plunged in a bath of pleonasm. When the infinitive cools, it is ready for use.

The question is often asked: Can other countries split the infinitive? I think we can safely answer "No." Though it is true that Russia, for one, is known to have large supplies of thesaurus hidden away behind the Plural Mountains, it is doubtful if the Russians have the scientific technique. They have the infinitive but not the know-how.

And that is something on which to congratulate our own brave pioneers in the field of grammatical research. Once it was thought that the infinitive could not be split—at least, not without terrible repercussions. We have shown that it is quite possible, given the necessary skill and courage, to unquestionably and without a shadow of a doubt, accomplish this modern miracle.—*Bell Laboratories Record*, October 1948.

Some Legal Aspects of Property Surveying

By S. A. BAUER

REGISTERED CIVIL ENGINEER AND SURVEYOR, CLEVELAND, OHIO

IT IS a strange fact that, although the science of property surveying is classified as a form of engineering, its essence is legal, rather than engineering.

Property surveying might properly be defined as the engineering interpretation, definition, and representation of legal documents of land ownership. In the practice of property surveying, the tools of the engineer, his technical equipment and his mathematical knowledge, are applied to the problem of interpreting and reducing to tangible and explicit form, the legal records of land titles. The handling of surveying equipment and the application of mathematics become, within limits, the operating mechanism, the primary problem being the varied and involved legal aspects of the case.

It is for this reason that mere facility in the use of transit and tape and a knowledge of trigonometry, though sufficient for surveys for building and construction layout, are not qualifications enough to enable a man to perform any but the most simple of property surveys.

It is unfortunate that this fact is not more widely recognized. It is even more sad than unfortunate, when members of the profession themselves fail to recognize the importance of the legal aspects of surveying.

The two most widely known texts on the subject are Skelton's *The Legal Elements of Boundaries and Adjacent Properties*, and Clark's *Treatise on the Law of Surveying and Boundaries*. The latter has been reprinted recently, and is now available, and efforts are being made to revise and re-edit the former. The subject, of course, is a broad one, that varies somewhat within the various legal jurisdictions, and is on occasion confused by contradictory decisions.

Any attempt to treat the subject by any single paper must limit itself to a few phases of the problem. The purpose of this paper is to touch upon only three of the more common (and frequently misunderstood) legal problems of the practicing surveyor, namely:

1. Apportionment or proration of errors.
2. The relative importance of deed and occupation.
3. The responsibility of the property surveyor.

APPORTIONMENT

Apportionment, proportionate measurement, or proration, as it is variously called, is a method for the distribution by equal division, of errors between record and actual distances. The great value of apportionment as a solution lies, of course, in its simplicity, but therein also lies its danger. Too often the theory of proration is used as a panacea of all the ills of boundaries, by the one rule all situations are handled. Its application is simple, it is easy to understand, it even sounds equitable. But its very simplicity makes it a potentially dangerous tool of the surveyor because seldom are the compound causes of a disputed boundary simple. It is therefore probable that the simple solution overlooks much that is important to the problem.

Too many surveyors have opened shop equipped with little more than a tape, a transit, and the rule of apportionment.

Property surveying is not that elementary.

Disregarding for the moment the use of the rule of apportionment in the division of government lands, where it has been set up by the General Land Office as a matter of expediency, the rule of proration is legally based on the assumption that the difference between measurement and record is due to a difference between the tape of the original surveyor and that of the present; in other words, it is a matter of calibration. The present day surveyor legally calibrates his tape against that of the earlier surveyor by measuring a known line and calculating a fixed relationship to be applied to all *related* measurements. In application, the theory can properly be carried further than that of mere calibration, but the indiscriminate use of the rule leads to much inferior and erroneous surveying. Since basically apportionment is a matter of calibration, it is of primary importance to determine an authentic comparison. Therefore, a first requisite of proration is positive determination of the reliability of beginning points. Too often errors, that are due primarily to erroneous beginning and end points, are "prorated out," causing greater confusion and error than before. Large errors are rarely properly prorated; erroneous end points are more probably the cause. Unfortunately, the correct determination of the end points is often a difficult task and the careless practitioner is often tempted to rid himself of his problem by apportioning the discrepancy in measurement.

Proration, as a rule, should be applied as a last resort rather than as the first and immediate expedient, as is so often done. It is also to be noted that apportionment is properly applied only to measurements that bear a fixed relationship to each other and the whole measurement, both as to time and intent, and are properly applied only in cases of subdivision of land by a single subdivider at a specific time. Any change in time or individuals involved in the subdivision tends to destroy the applicability of the theory of calibration, since the present tape cannot be calibrated against the separate measurements of several earlier tapes.

Too much emphasis has been given the rule of proration and only seldom is it properly applied except in the distribution of small errors. Skelton states "that the courts do not hold the rule in high regard, is established by the relatively few cases in which it is resorted to, and the qualification that it is applied only in the absence of any marking on the ground of the division lines between two lots."

There is another erroneous belief among many surveyors that in dividing a line or area, the precision of measurement is unimportant so long as the intermediate points are set by apportionment. That belief is current but unsound. It assumes the complete absence of compensating errors; it assumes the uniform and constant value of all of the various errors that are normally considered as accumulating but which actually act in the manner of compensating errors in their variation of quantity in various parts of the line insofar as their effect on the position of any intermediate point is concerned.

This writer has been working for the past 2 years on a study to determine his ability to reproduce a specific point between two fixed geodetic control points operating with a procedure having a known average accuracy. Although that study will require much more time for completion, it is already clear that the ability to reproduce a point is greatly dependent upon the accuracy of the original

observations; that proration and distribution of error will *not* eliminate error from position of the final point; that even in fixing a point on a straight line between fixed end points, an error of position must be expected; and that error in general decreases as the precision of the overall measurement increases.

It is the opinion of the writer that instruction on the legality of proration should stress its negative factors more than its positive. The simplicity and ease of operation of the rule of apportionment make it only too well known. Its limitations, however, are too often not known. The improper use of the rule has introduced a large number of new property line problems, compounding those of the past.

RELATIVE IMPORTANCE OF DEED AND OCCUPATION

The practicing profession suffers considerably from a lack of appreciation of the primary importance of the deed as the legal evidence of title over occupation and possession, under present day requirements of title. It is too often assumed that possession alone counts in title. Often the location of possession is a much simpler task than the relocation of the calls of the deed and chain of title.

The use of land for more than the statutory period does not automatically give title to the adverse owner. Only proper court action can convey title.

In earlier days, occupation alone was held in more esteem than it is today in surveying. And today in rural communities occupation is given more importance than in large urban centers.

High land values, small parcels, and the extensive improvements in urban areas all tend to make the deed and its precise wording of greater significance than that given in rural areas. The tendency of lending organizations and title companies is toward ever-increasing strictness in the wording and importance of the deed.

Title practice, dealing as it does with the written deed rather than the property itself, must, of necessity, pin its responsibilities to the written deed. As a result, the interpretation of deeds in urban areas, particularly, has become an increasingly meticulous process. This fact in no way lessons the responsibility of the surveyor to indicate any and all occupation adverse to the title. Rather, it makes it of more importance to indicate the relationship between title and possession while holding title as the basis. It does, however, tend to limit the surveyor from using the easy "way out," namely, that of merely locating in the nearest available occupation without regard to the proper calls of the deed. The point is of such basic importance that the opening sentence of the *Technical Standards for Property Surveys,* compiled and adopted by the ACSM, is as follows: "Every parcel of land whose boundaries are surveyed by a licensed surveyor should be made conformable *with the record title boundaries* of such land."

Needless to say, where occupation is adverse to title and in sufficient degree to justify a change, (i.e., actual, open and notorious, exclusive, hostile, and continuous for the statutory period) the record should be made to agree with such occupation by proper legal action and the surveyor should so recommend to his client, furnishing the client with full data on both title and occupation.

Too often attempts to clarify title result in even more confusion due to insufficiency of data and lack of appreciation of the factors involved. In 1925 an apartment project was begun in the City of Cleveland on a property on which existed an ornamental iron fence which was some 3 feet south of the true property

line. The first operations of the excavator removed the fence. The adjoining owner stopped the operations by an injunction suit, resulting in a journal entry with the court granting the plaintiff title to the land "as marked by the iron fence." The fence was already destroyed. No record was included in the court records as to the position of the fence, but title was conveyed by court to a line "as marked by the iron fence"—destroyed and unlocated.

Proper surveying procedures should have located the fence in its relation to the title lines. It seems reasonable, however, that a court should realize the importance of clarity, particularly under circumstances where it attempts to correct a property line already in question.

As with the too free use of the rule of apportionment, the haphazard use of occupation irrespective of the calls of the deed, leads to many difficulties of property boundaries, and seriously complicates the problems of title examination.

THE RESPONSIBILITY OF THE PROPERTY SURVEYOR

The function of ordinary practitioners, particularly those in urban areas, is primarily that of an impartial fact-finder. The surveyor is not the agent of any court or governmental body. He has no legal authority. He cannot "determine" titles. He cannot legally decide disputed lines. Even his opinion as to the proper interpretation of conflicting calls in a deed has no legal value. His responsibility is merely that of assembling or determining all of the pertinent facts of titles and occupation and presenting them in their proper relation.

However, it is a strange and satisfying fact that, having none of the privileges of lawyer, judge, or court, the property surveyor can and does exert the influence of all.

One of the chief rewards of this profession of ours is the willingness of title companies, lawyers, courts, and owners to accept the opinion of a surveyor on matters of title. This is not because he has any legal status, but merely because he has presented his case with a thoroughness and sound reasoning that, combined with an established reputation within his community for technical skill, knowledge and integrity, give his work and word an authority that is accepted by those who have the power and function to translate his opinions into decisions with the weight of law. In some 25 years of practice in the City of Cleveland, this writer has appeared in court only once to dispute the work of another surveyor. On the other hand, large numbers of titles have been changed and corrected without court action, merely by the willingness of the title companies to accept work from this and other offices where such work indicated careful, studious and detailed investigation of conditions, by surveyors of recognized professional standing. Acceptance of a title change by a major title company in practice generally carries all of the weight of a court decision, since rarely is it contested. That extra-legal privilege of the surveyor is the best indication of the service he is rendering the community. Too great emphasis cannot be placed upon that phase of property surveying in text books and in teaching of the art. Attainment of that extra-legal right means an investment of years of scrupulously careful work, clear, logical thinking, honest approach and a feeling of public responsibility. The profession would gain by more emphasis on that important, though intangible, reward for services rendered and on the qualities of practice by means of which it may be attained.

The Relationship Between the Surveyor and the Title Company

By JAMES T. KNIGHT

VICE-PRESIDENT, LAWYERS TITLE INSURANCE CORP., RICHMOND, VA.

THE word "Relationship," by its very structure, is a relative term, and when used with respect to individuals, groups, or classes, necessarily imports obligations and responsibilities, one to another. Let us, therefore, consider what are the obligations and responsibilities of each to the other, the surveyor and the title company.

Your work is an exact science, and so is ours, not only exact, but exacting. There is no substitute for accuracy in your work or that of the title company. It is, among other things, the accuracy and sufficiency of your findings that the title company is called upon to insure. Inaccuracy and insufficiency in your findings can result in substantial loss to the title company, and such losses have occurred.

Title companies have a deep appreciation of the difficulties and problems you surveyors and mapmakers often encounter, some of which we have in common. I have in mind, especially, weird and unusual record descriptions of property. In the wording of one old deed, a certain boundary is described as terminating at "A stump where Daniel Harrington licked William Jones." In the early days of the township of North Hatfield, Massachusetts, a road was laid out which was described as, "Running from Poching Meadow to the stream where Old Mister Doolittle's horse died." In Winston Salem, North Carolina, a large office building is situated on a lot formerly described as "Beginning at the Northeast corner of the Old Asparagus Bed." But even an asparagus plant is a more permanent monument than that relied upon in an instrument to which my attention has been directed. This particular deed described the land as "Beginning at a point where you and I stood talking yesterday." When descriptions of these types are encountered, we depend on you to find out where Mr. Doolittle's horse actually died and the location of the "Old Asparagus Bed."

You gentlemen are from many different localities. As the laws pertaining to real estate differ in those localities, so is there a difference in the requirements of title companies with respect to surveys. But, basically, those requirements are the same. Title companies require that your surveys be accurate, and that they disclose all matters of a physical nature which have a bearing upon the use by the owner, or another, of the land surveyed. While a standard method of depicting your findings is, I believe, desirable from the standpoint of the title company, there is no such standard method now being employed.

There are principally two kinds of title insurance. The first is called "Owner's Title Insurance." Mr. *X* invests his savings in a home for himself and his family for which he pays cash; or perhaps he cannot pay the full purchase price in cash and has to borrow money in order to pay the balance. If he

Presented at Eighth Annual Meeting of the American Congress on Surveying and Mapping, Washington, D. C., June 21–23, 1948 by M. S. McCollum, Ass't. Sec'y., Lawyers Title Insurance Company.

loses his home because the title is bad, he loses not only his savings, but he also has to pay back the money he borrowed. If Mr. *X* is smart, he buys "Owner's Title Insurance," so that if he does lose his home the insurance company will pay him its value, and then he will have not only his savings, but also funds with which to pay back the money he borrowed.

The other kind of title insurance is "Mortgagee Title Insurance." This merely means insurance for the protection of the man or company which lends money to Mr. *X* on the security of his house and lot. Mr. *X* goes to his bank and says that he wants to borrow $6,000 and will put up his $10,000.00 home as security. The bank is willing to make the loan, but tells Mr. *X* that he will have to furnish, at his expense, a policy of "Mortgagee Title Insurance" for its protection. Then if the loan is not repaid, and the bank can't sell the house because Mr. *X*'s title turns out to be bad, the title insurance company will repay to the lender the money it lost because of the bad title.

Title companies must have some reliable basis on which to issue title insurance policies. That basis is represented by the opinions of attorneys based upon their own examinations of the title or on abstracts of title prepared by approved abstract companies. In many cities, title companies have their own title plants and staff attorneys.

Where now, one may ask, does the surveyor fit into this picture? That can best be answered by this statement: "Title" simply means the right of ownership of property. The right of ownership can be affected by matters which can not be determined from an examination of the records, but only from a survey and inspection of the property. An attorney's opinion of the validity of title is limited to what is disclosed from an examination of the public land records. Here the surveyor is the man upon whom the title company depends. Without his service the title company would of necessity be required to issue a form of policy under which there would be no coverage of survey matters. Title companies depend upon his depicting conditions which may affect the right of ownership with the same degree of reliance as is placed upon the attorney's certification of the validity of the title. Time will not permit me to mention every possible condition which could affect the right of ownership of real estate and should, if existing, be disclosed on a survey. I shall, therefore, confine my remarks to a few illustrations:

Let us consider the survey with relation to restrictive covenants. Such covenants are found principally in chains of title to urban property. They vary in terms, but their chief effect is to place a limitation upon the use and occupancy of the property. Title companies are required to insure that these restrictive covenants have not been violated and this fact can be determined only from a survey of the property. I have seen surveys showing only the location of the main walls of the building with respect to the lot lines; no location of the porch or other projections were shown. While in some instances this might be sufficient, such a survey would not be acceptable in a case where there is a restrictive covenant which in effect requires that the building, or any part thereof (which would necessarily include a porch, or stoop), shall be no nearer than a stated distance from the front or side lot line, or a building restriction line. Unless the location of the porch is shown on the survey in such a case, the title company is not in a position to insure whether or not that particular covenant has been violated. It becomes necessary, therefore, that the surveyor

amend his survey, which often results in a postponement of the closing of the sale or loan with attendant embarrassment and inconvenience not only to the title companies, but to other interested parties.

To avoid such situations, I recommend that whenever you are requested by an attorney or title company to make a survey of a property that you have them furnish you with a verbatim copy of any restrictive covenants which might be imposed against the property. Upon a reading of the convenants, you can then appreciate better the requirements of the title company or attorney, bearing in mind, especially, that the title company may be called upon to insure that none of the convenants has been violated.

It is equally important that the survey disclose all rights of way, old highways, abandoned roads, lanes, or driveways, particularly *joint* driveways, drains, sewers, or water pipes over and across the property, the closing of which might affect the rights of adjoining owners, which may have been acquired by the user with nothing in the public records to disclose the right. We realize that it may seem a hardship to have to check sewer and water maps, but put yourself in the position of an owner across whose property the neighbor's sewer runs, and it becomes clogged and a big hole has to be dug in *your* basement to unclog the neighbor's sewer that has been there a sufficient length of time to acquire *by user* the right to maintain the sewer across your property. Failure to show such a condition, if it exists, could easily result in a loss to the title company, for such an undisclosed condition ordinarily affects the rights of others, even though such rights may not be a matter of record, and when not a matter of record, would not be reported by the attorney to the title company.

Likewise, it is essential that all telephone, telegraph or electric power poles, wires or lines, located on or crossing the property be shown on the survey. If such conditions do exist, it would indicate that there are rights of others in and to the property, and exception thereto should be made in the title insurance policy. Cemeteries or family burying grounds are in that category.

If time permitted, we could consider in detail many other points wherein there is a direct relationship between the *survey* and *title policy*. For example, there are matters pertaining to party walls, encroachments, overlaps, overhangs, structural appearance of buildings, boundary fences and hedges, the showing of acreage or area of property, the proper denoting of courses and distances, the showing of stakes or other monumentations appearing on the premises, as well as a sufficient identification of the property. Since all of these elements and many others are matters which relate to and have a direct bearing upon the title, their existence or nonexistence should be made known to the title company through the survey.

When you are engaged in the making of a survey, let yourself be placed for that time in the position of a representative of the title company who desires to know everything about the property from a physical standpoint affecting the title thereto, and consider it your obligation to show the existence of any one or more conditions of such nature. Those of you who recognize such a responsibility, and furnish the data which from the standpoint of the title company is most vital, are those to whom the title company feels the greater obligation. It follows, therefore, that where the placing of a request for survey is left to the title company, the surveyor whose work has proven most satisfactory to that company is the surveyor who will be asked to perform the service.

Plastic Relief Models

By ALBERT A. STANLEY

CHIEF, GEOGRAPHIC SECTION, UNITED STATES COAST AND GEODETIC SURVEY

DURING the war period a critical need developed for lightweight terrain models to be used for instructing Army Air Forces' pilots and navigators in map and chart reading. For instructional purposes it was found necessary to illustrate the treatment of landforms on the conventional contoured map, by a visual representation of the terrain. By employing relief models for this purpose, the significance of contours and other symbols employed in map and chart production were effectively demonstrated to our airmen, who, in most cases, were not experienced in map and chart interpretation. Under the war work program of the Coast and Geodetic Survey, topographical models were produced of various areas from Vinylite—a plastic sheeting—by a new technique of modeling developed over a period of years through research work by personnel of the Survey.

The terrain model provides a more objective method of cartographic representation, which complements and accentuates the relief effect attained by contours. With the introduction of the contour method of showing relief, approximately a century ago, the use of contours to portray configuration of terrain with accurate elevations, has increased in importance. It is now recognized that this technique of terrain representation may be improved substantially by employing relief models which retain all standard map details, including contours and gradient tints. It is first necessary, of course, to obtain a suitable contoured map of the area before the construction of a terrain model can even be started.

In the early stages of the development of aeronautical charts in the Coast and Geodetic Survey, it became apparent that a system was desirable, whereby the contour lines and gradient tints representing vertical relief on the charts should be further accentuated by relief shading that would provide a 3-dimensional effect. In seeking a way to provide for this necessity, Mr. John J. Braund, in 1928, while engaged in aeronautical chart compilation, conceived the idea of printing contour maps on sheets of soft aluminum and embossing the relief on these sheets to fit the configuration of the terrain, as shown by the contours. This method produced a light precise relief model, complete with all the details of the original flat map. By continually improving on this idea, Mr. Braund has been instrumental in the development of special methods, processes, and equipment for duplicating lightweight terrain models on a practical quantity-production basis.

The initial experiments along this line for the improvement of aeronautical charts, visualized the preparation of a photographic reproduction of a model of the map or chart area that could be over-printed on the conventional chart, to emphasize the vertical detail, but this process did not develop past the experimental stage. It was found that the modeling process developed during these experiments contributed greatly to the previous conceptions of model construction. The process increased in importance as a result of military requirements for precise relief maps of areas of special tactical importance that could be easily reproduced and handled. It was found desirable to develop lightweight models

Reprinted through the courtesy of *The Military Engineer*, July 1947.

that reflected the vertical detail of all important features of relief and also that carried suitable details pertaining to the drainage and cultural features of the terrain, especially for illustrating the approach to a military objective. These requirements lent importance to the experiments then being carried on in the Survey to perfect a method of producing models that were light in weight, durable, and readily produced in quantity.

The Braund process of producing relief models, on which the production of plastic models is dependent, has the great advantage of preserving accurate topographic and cultural features and at the same time employing a lightweight medium that can be easily handled and readily reproduced. It is estimated that the finished model produced by this process is twenty times lighter and approximately ten times cheaper to construct than other known processes. An added advantage is the maintenance of almost exact correlation between the various map features by decreasing to a minimum the shrinking or stretching of the medium employed. Nor are the models thus produced affected by atmospheric conditions.

MODEL COMBINING LAND AND SUBMARINE TOPOGRAPHY

The method of producing plastic relief models which retain all the conventional detail that appears on the basic map, has been improved to a considerable extent since the war. The improved process has resulted in the production of a lightweight relief model, combining a land area in the northeastern United States with the offshore submarine topography in the adjacent ocean area. The basic map selected for this model was the Map of Northeastern United States, and the adjacent continental shelf and slope showing the relation between land and submarine topography. The map was compiled from aeronautical charts of the Coast and Geodetic Survey and from a series of Continental Slope Charts on the scale of 1:120,000. The special submarine charts were developed by Dr. A. C. Veatch, a noted geologist, Lt. Comdr. Paul A. Smith, and Mr. Harold W. Murray, from intensive hydrographic surveys by the Coast and Geodetic Survey. These charts were published as part of Special Papers No. 7, by the Geological Society of America, in 1939, with the co-operation of the Coast and Geodetic Survey. Without this important study of the underwater topography along the Atlantic Coast, the combination relief model could not have been produced.

The submarine configuration illustrated by the spectacular canyons and valleys indenting the continental shelf of the United States, extending from Georges Bank to Cape Henry, are the most conspicuous features appearing on the model. These canyons had enjoyed relative obscurity until recent years, when attention was directed to them by the comprehensive hydrographic surveys of the Coast & Geodetic Survey.

The 5-fathom contours on the shelf were obtained from large-scale original surveys contoured at an interval of one fathom. The continental shelf, comprising the zone of the submerged continental margin from the coast offshore to the continental slope (in depths of about 100 fathoms), due to the regularity of the ocean floor in this area, could be contoured at a much closer interval than on the slope. The continental slope formed by the declivity from the offshore border of the shelf is characterized by a marked increase in gradient, therefore only the 100-fathom contours could be shown in this area of the model. The change from the 5-fathom to the 100-fathom interval was introduced near the 60-fathom line at

the southern limitations of the model and at about the 80-fathom line in the Georges Bank region. The change in the contour interval for the intervening area varies progressively between these limits.

The land area of the model is represented by conventional map treatment, including four gradient tint tones which emphasize the contours at 1000-foot intervals. Cities and towns are classified according to the treatment employed on aeronautical charts and the projection is printed in black, with place names and boundaries also included on the black plate. Various submarine canyons to which names have been assigned, are indicated on the black plate.

The land area extends from Albemarle Sound on the south, northward to include all of the Atlantic Coast to a point just north of Portsmouth, New Hampshire. The northwesternmost corner of the model includes Rochester, New York, and the southern shore of Lake Ontario.

PRODUCTION OF MODELS BY THE BRAUND PROCESS

This new technique of producing plastic relief models is dependent entirely upon the Braund Reliefograph, which is required to develop the original cast. This machine was originally developed to produce only an original model by the method described by Col. Harry H. Blee, in a previous issue of *The Military Engineer*. By continued experiments in the Coast and Geodetic Survey, additional special equipment was constructed which made possible quantity production of duplicate models. Still greater improvements in this type of relief modeling are to be expected from future improvements in equipment and technical knowledge.

The first step in the production of a model by the Braund process is the preparation of the original or master relief model. The original model is produced from a stock sheet of semi-soft aluminum, approximately 0.010-inch thick, by embossing from the back of the sheet. The embossed original aluminum model is then used to construct a mold for producing, in quantity, duplicate models from plastic sheeting.

The three principal elements of the Reliefograph are a high-speed electric motor-driven pulsating embossing tool, a rubber-faced embossing table and a series of tension grip embossing frames of various sizes, together with a convenient arrangement of the necessary controls and gauges for accurate work. All of these are carried on the rigid structural steel base suitable for use by a mobile map reproduction unit.

The Braund Reliefograph (fig. 1) employed in this process was procured with funds made available by the Civil Aeronautics Administration, another Bureau of the Department of Commerce. The splendid results obtained to date in developing this new process of producing models is due, in large measure, to the close co-operation existing between the Coast and Geodetic Survey and the Civil Aeronautics Administration.

The sheet of aluminum containing a reproduction of the map or chart forming the base for the model is locked in the machine by tightening the tension grip clamps which hold the sheet firmly in position parallel to the plane of the embossing table and under drum head tension. The embossing frame operates on machined guides and is intended to slide freely in order that the work area may be kept in a convenient location over the embossing table. The embossing table is mounted at the center of the machine between the guides. The height of the

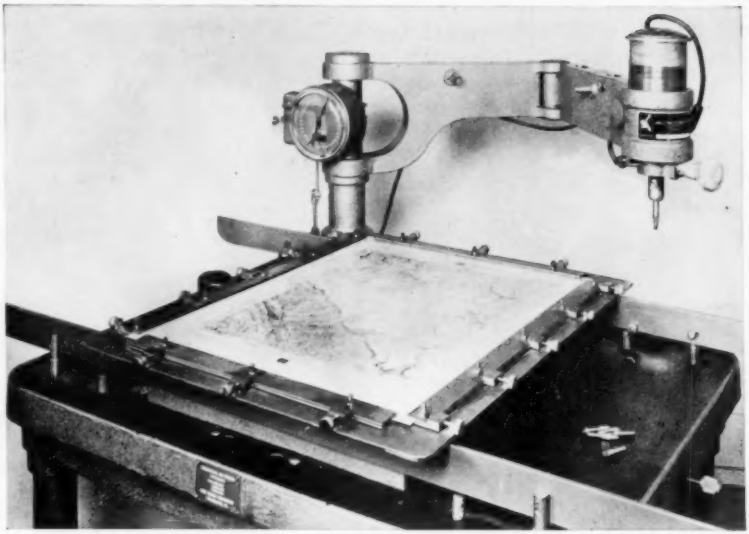


FIGURE 1.—The Braund Reliefograph.

embossing table is kept in proper relation to the limiting plane of the embossing tool by means of a line gauge along the metal frame. Through the aid of this gauge the altitude divisional register is set and the machine is then electrically operated. Each contour is embossed separately to its predetermined height by the pulsating hammer.

A special chuck designed to accommodate a variety of rubber embossing tips is adjusted to the end of the embossing tool. In addition to the three principal elements, other component parts of the Reliefograph include a large handwheel which provides for the raising and lowering of the frame controlling the limiting working plane or depth of punch. A universal altimeter indicates on a dial the position of the working plane. The rubber face of the table is kept in contact with the aluminum sheet when the embossing tool reaches the predetermined limit of the working plane corresponding to the particular contour level at which the embossing is done. A rheostat foot control pedal governs the rate of pulsation of the tool.

The pulsating hammer comprising the embossing tool can be moved in a horizontal plane until it is over the first or lowest contour line. The areas enclosed by each of the contour lines are worked successively, beginning with the initial or lowest contour and finishing with the highest. Each line is embossed down until the metal touches the rubber base of the embossing table to the prescribed depth that the pulsating embossing tool will reach. The table and embossing tool are lowered for each succeeding contour level by the amount corresponding to the contour interval at the vertical scale selected for the map.

After all contours have been successively treated in this manner, the soft metal model is sealed with a lightweight quick-hardening plastic material. The material usually employed is hydrostone or paraffin, which holds the model in a rigid

position. Thus, what is termed as the original model is now turned right side up and mounted in a rigid supporting frame.

A female cast can now be produced by covering the original model with the required amount of hydrostone. Rods in the original are for leaving holes in the female cast at selected points of maximum elevation to allow for the vacuum process. After the female cast has hardened it can then be removed and placed in the duplicating machine (fig. 2) which is comprised of a vacuum box suitable in size to accommodate the completed cast.

DUPLICATION OF MODELS

The process has now reached the stage where duplicate copies can be produced rapidly through use of the female cast, together with the duplicating machine. It is required for the production of each separate model that a sheet of opaque white vinylite (fig. 3) be prepared, with the map or chart details printed in conventional colors for the various map features. This reproduction is usually accomplished by printing successively, on a proving press, from the prepared printing plates for the flat map. The map thus produced in conventional colors on the plastic medium is placed over the female cast, with the printed side in contact with, and also in registry with, the mold which has been placed in the duplicating machine.

The lid of the duplicating machine has been constructed with heating elements that can apply heat as required. The lid of the duplicating machine is lowered and locked tight to the body of the machine. (Fig. 4.) The air is withdrawn from the vacuum chamber through the use of a vacuum pump. By creating the vacuum the sheet of vinylite containing the map image is pulled tightly against the mold. The heating unit in the lid of the frame is applied to the vinylite. As the heat increases, the vinylite becomes soft and is drawn down into the female mold with considerable force. The plastic is drawn to the lowest depth in the mold with the application of the maximum vacuum pull and when the proper degree of heat is reached.

The embossed vinylite map is then allowed to cool in the mold with the vacuum pull maintained. During the cooling period, air is allowed to circulate in the frame after the heating units have been turned off. When the cooling process has been completed, the lid of the duplicating machine is raised and the completed vinylite duplicate shell model of the original is removed.

The plastic model containing all conventional map features in corresponding colors and in proper relationship is now completed and ready to be mounted. For this purpose, the lightweight sheeting, such as cardboard of suitable weight to maintain rigidity (or masonite board if weight is not too much of a factor), is used to mount the plastic model by applying opaque tape along the edges. Presentable mounting has also been accomplished by using light wooden frames to hold the plastic models. When the lightweight wooden frame is used for mounting, the model may be suspended from the wall or displayed on an easel. Satisfactory results have also been obtained by embossing a decorative border in the plastic base of certain models, along their outer margin.

THE USE OF MODELS

There are many and varied uses for the relief models. Technical instruction in college, as well as elementary studies in geography, are among the many uses

URE 2.—Operator using the duplicating machine.

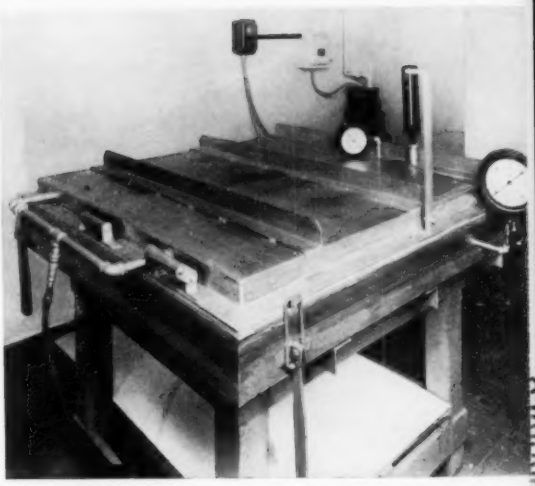


FIGURE 4.—Duplicating machine with lid closed, in operating position.

URE 3.—The plastic sheet containing all details before embossing.

FIGURE 5.—The finished embossed relief model made from figure 3.

to be made of the models in our educational system. Indication has been given that the models should be especially effective in the study and analysis of geologic formations. This is more true in the case of the combination model of terrain and submarine features where the continental shelf and submarine canyons are impressively displayed.

Planning in various branches of engineering, including power projects, transportation, flood control, and many others, should benefit by these terrain representations. Municipal and regional planning in both urban and rural development may also be considered as important uses for lightweight models. It may be said that wherever maps are used, there are few instances where some form of relief representation does not have an effective application.

Among the more interesting of the newer models is one of the San Francisco Bay area, employing as its base an aeronautical chart on the scale of 1:250,000, with the vertical scale exaggerated ten times. The model retains the contours and all other terrain details of the published aeronautical chart. An interesting adaptation of this model is the addition of the triangulation net of the area from the geodetic control surveys conducted by the Coast and Geodetic Survey. Each of the observed angles in the arcs of triangulation for this area is strung on the model with red yarn, then secured to the tops of mountains or high spots on the position of the established triangulation station. The path followed by the precise level lines located by the Survey are displayed by use of cellulose tape in a contrasting color. This demonstration illustrates further the use that may be made of relief models as an educational medium in presenting effectively surveying and mapping principles.

Fastest Camera Shutter Known to Science Revealed

THE FASTEST camera shutter known to science, capable of operating at a rate of 100,000,000 frames per second, was revealed at the Navy's dedication of the new Michelson Laboratory at the Naval Ordnance Test Station, Inyokern, Calif. It is in the Zarem camera, invented by Dr. A. M. Zarem.

The Zarem camera is about 25,000 times faster than the fastest motion picture camera commercially available. If motion pictures of a bullet leaving the muzzle of a gun were taken at this rate of 100,000,000 frames a second and projected on a screen at the normal rate, the bullet would appear to travel about four feet an hour.

A so-called Kerr cell is the secret of this fast shutter. This cell, long used by scientists, is a glass tube filled with nitrobenzene in which a pair of electrodes is immersed. The Kerr cell is placed between two polarizing plates so set that the polarized light emitted through the first is in the wrong plane to pass through the second. When high voltage is applied to the electrodes in the Kerr cell, the state of the polarization of the polarized light is immediately altered, allowing the light image of the subject being photographed to pass the second plate and on through the camera lens to the film.

By controlled timing of the voltage, photographic records with an effective exposure time of one hundredth of a millionth of a second have been obtained. The camera is designed for use in studying certain rapidly changing phenomena which heretofore science has been unable to observe and record accurately.—*Science News Letter*, May 15, 1948.

Surveying and Mapping News

Members are requested to send in surveying and mapping news items for publication in SURVEYING AND MAPPING.—EDITOR.

CURRENT SURVEYING AND MAPPING LITERATURE

MAGAZINE ARTICLES

THE USE OF AERIAL PHOTOGRAPHS IN THE LOCATION OF THE STUART HIGHWAY. A. E. G. Close, *The Australian Surveyor,* June–September 1947.

ASTRONOMICAL GROUND CONTROL FOR AIR SURVEY OF NEW GUINEA, 1939–1940. H. A. J. Fryer, *The Australian Surveyor,* June–September 1947.

A QUICK METHOD OF TAKING TOPOGRAPHY. Frederick Butterfield, in Appendix "H" to Report of *Proceedings of the 43rd Annual General Meeting, Corporation of British Columbia Land Surveyors,* January 1948, Vancouver, B. C. (Explains a rapid method of topographie reconnaissance employing the Wild 1-second instrument in conjunction with the planetable.)

AN EXPEDITION TO THE LLOYD GEORGE MOUNTAINS, NORTH-EAST BRITISH COLUMBIA. F. S. Smythe, *The Geographical Journal,* April–June 1948. (An account of expedition of 1947; almost the first expedition of this sort in which supplies and lines of communication were maintained by air.)

WILDWOOD—AN OUTSTANDING COMMUNITY PLANNING DEVELOPMENT. H. E. Beresford, *The Canadian Surveyor,* July 1948.

MODERN INFLUENCES OF THE UNIVERSITY ASPECT OF PROFESSIONAL TRAINING IN SURVEYING. C. A. Hart, *Empire Survey Review,* July 1948. (Lecture delivered at University College, London, to inaugurate the newly established Chair of Surveying and Photogrammetry.)

HEIGHTS BY ANEROID BAROMETER. D. R. Crone, *Empire Survey Review,* July 1948. (A discussion of wet-bulb method employed by Survey of India in the consideration of "Humidity Correction" for barometric heights.)

DRAUGHTSMEN'S AND COMPUTERS' EXAMINATION, 1947. (Land and Surveys Department, New Zealand.) *The N. Z. Draughtsmen's Journal,* July 1948.

TRANSVERSE MERCATOR FORMULAE. T. C. B. Redfearn, *Empire Survey Review,* July 1948. (A fuller development of the formula required for Ordnance Survey triangulation and mapping of Great Britain.)

OBSERVING POLARIS IN DAYLIGHT. S. E. Evans, *Empire Survey Review,* July 1948. (Brief practical approach to quick location of Polaris in daylight.)

THE CASE OF THE BASHFUL MOUNTAIN. *Science Illustrated,* August 1948. (A report of the expedition by Milton Reynolds into Tibet to locate the mysterious peak reported to be higher than Mount Everest.)

SYMPOSIUM ON PHOTOGRAMMETRIC TECHNIQUES. (Compiled by Kenneth E. Reynolds.) *Photogrammetric Engineering,* September 1948.

SYMPOSIUM ON EDUCATION. (Compiled by G. C. Tewinkel.) *Photogrammetric Engineering,* September, 1948.

DISCUSSION OF SPATIAL TRIANGULATION WITH THE ZEISS STEREOPLANIGRAPH. Robert S. Brandt, *Photogrammetric Engineering,* September 1948.

EXPLORING THE "MYSTERIOUS". Charles E. Hendrix, *The Earth Science Digest,* September 1948. (A discussion of caves and cave formations.)

INVESTIGATIONS SHOW ADVANTAGES OF EXTREMELY WIDE-ANGLE LENSES IN AERIAL MAPPING. *Civil Engineering,* September 1948.

SHORE EFFECTS OF COASTAL STRUCTURES. Donald F. Horton, *The Military Engineer,* September 1948.

PLANE COORDINATES FOR HIGHWAY MAPS. J. C. Carpenter, *The Military Engineer,* October 1948. (Describes the use of plane coordinates in the highway mapping program promoted by the Public Roads Administration.)

ON THE LAMBERT CONFORMAL PROJECTION AS APPLIED IN CHINA. J. T. Fang, *Empire Survey Review,* October 1948.

HOW TO EXPLORE A CAVE. *Science Illustrated,* November 1948. (An illustrated article describing the experiences encountered in exploring a cave near Franklin, West Virginia, including the eerie silences, darkness, rock formations and mapping unknown passages.)

BOOKS AND PAMPHLETS

GEOMORPHOLOGY. C. A. Cotton. *John Wiley & Sons,* New York. 1946. 505 pages. $6.00. (An introduction to the study of land forms.)

THE NATURE OF GEOGRAPHY AND THE ROLE OF THE LOCAL SOCIETY. Norman Pye. *The Journal of the Manchester Geographical Society,* Vol. LIII, 1945–47. (Address delivered at the 62nd Annual General Meeting of the Manchester Geographical Society, held in Town Hall, Salford, May 1947.)

GLACIAL GEOLOGY AND THE PLEISTOCENE EPOCH. Richard Foster Flint. *John Wiley & Sons,* New York. 1947. $6.00. (Geographers will be particularly interested in the reconstruction of the history of the glacial epoch.)

FUNDAMENTALS OF EARTH SCIENCE. Henry Dewey Thompson. *D. Appleton Century Co.,* New York. 1947. 450 pages. $3.75. (A survey of earth science covering one semester.)

BIBLIOGRAPHY AND INDEX OF GEOLOGY EXCLUSIVE OF NORTH AMERICA. Marie Siegrist and Eleanor Tatge. *Geological Society of America.* Vol. 12. 1947. 359 pages. $3.50.

FIRST SUPPLEMENT, 1948: BIBLIOGRAPHY OF THE GEOLOGY AND NATURAL RESOURCES OF NORTH DAKOTA. Chrissie E. Budge. *North Dakota Research Foundation,* Bismarck, North Dakota. 90 pages. (Free upon request.)

PHYSICAL GEOLOGY. Chester R. Longwell, Adolph Knoff, and Richard Flint. *John Wiley & Sons,* New York. Third Edition. 600 pages. $5.00. Illustrated. (A text book revised and enlarged.)

GLOBAL GEOGRAPHY: A WORKBOOK IN WORLD GEOGRAPHY. Paul R. Hanna and Joseph E. Williams. *Scott Foresman and Co.,* Chicago. 1948. $2.40. (The publication is designed to teach world geography as an active influence in the lives of people throughout the world.)

ELEVATIONS IN FLORIDA, BULLETIN NO. 32. Herman Gunter. (The Florida Geological Society.) *The E.O. Painter Printing Co.*, Deland, Florida. 1948. 1158 pages. (A comprehensive listing of all permanent bench marks in Florida.)

GENERAL CARTOGRAPHY. Erwin Raisz. *McGraw-Hill Book Co., Inc.*, New York. 1948. 354 pages. $6.00.

THE SOUTH AMERICAN HANDBOOK, 1948. Howell Davies and W. H. Wilson. *Trade and Travel Publications.* Twenty-fifth Edition. 778 pages. $1.50. (A yearbook and guide to the countries and resources of South and Central America, Mexico, and Cuba.)

THE UNKNOWN MOUNTAIN. Don Munday. *Hodder and Stoughton,* Warwick Square, London, E.C.4. 1948. (A volume describing the experiences of a Canadian mountaineer in discovering the Mystery Mountain of the Coast Range known as Mount Waddington.)

A CHRONOLOGY OF SCIENTIFIC DEVELOPMENT 1848–1948. K. L. Horvitz and Eleanor Carmichael. *American Association for the Advancement of Science.* 99 pages. Free from Physics Dept., Purdue University, Lafayette, Ind. (Covers major achievements of the last century.)

CROSS-INDEX TO THE MAPS AND ILLUSTRATIONS OF THE GEOLOGICAL SURVEY AND THE MINES BRANCH (BUREAU OF MINES) OF CANADA, 1843–1946. Carl Faessler. *Universite Laval,* Quebec. 1948. 525 pages. $10.00. (This comprehensive book offers complete lists of all numbered maps published by the Canadian Geological Survey and the Bureau of Mines, since their beginning, together with complete lists of publications.)

PRACTICAL ASTRONOMY. Jason John Nassau. *McGraw-Hill Book Co.*, New York. 1948. Section Edition. 311 pages. $5.00.

BEACH EROSION IN NORTH CAROLINA. (Bulletin No. 37 of the Department of Engineering Research of the School of Engineering.) C. E. Feltner. *North Carolina State College,* Raleigh. 1948. 39 pages.

HISTORIQUE DE LA CARTOGRAPHIE DE LA NOUVELLE CARTE DE FRANCE. M. Huguenin. *L'Institut Geographique National.* 1948. 191 pages. Illustrated. (A comprehensive account of cartographic developments to date in France and colonies.)

—A. A. STANLEY

DISTINCTIVE RECENT MAPS

A recent Library of Congress accession is the "Soil Map of the European Part of U.S.S.R.," published in 1947 by the V. V. Dokuchaev Memorial Soil Institute of the Academy of Science of the U.S.S.R. The map was compiled by E. V. Lobov and N. N. Rozov under the direction of H. H. Lebedev. It is on the scale of 1:2,500,000 and printed on four sheets, each measuring 32 by 23 inches. More than ninety soil types are indicated by color and symbol designations. Title, legend, and place names are in Russian.

The Ural Mountains embrace one of the most interesting geological and topographical areas of the U.S.S.R. Of especial interest, therefore, is the "Geomorphological Map of the Urals," issued in 1945 by the Urals Section of the Geological Division, Ministry of Geology, U.S.S.R. The map proper includes eight sheets, each 25 by 21½ inches, and two additional sheets of the same size show profiles of the region. The legend is printed on two smaller sheets, each measuring 14½ by 22½ inches.

The map was prepared under the editorial direction of Y. S. Zdelstein, A. P. Sigov, and I. P. Gerasimova.

A 96-page explanatory booklet accompanies the map. Prepared under the direction of Zdelstein and Sigov, the booklet was published in 1948 by the Ministry of Geology U.S.R.R., (Moscow & Leningrad).

Our motorized world is powered largely by petroleum and its products. The United States leads the world in the production of oil and gas, but our resources are far from unlimited. Interest in the problems of petroleum production and distribution is evident in a number of new oil and gas maps of the United States which have appeared during the last 2 years. Several are here listed:

United States Department of the Interior (Geological Survey). "Oil and Gas Fields of the United States." Prepared by Paul Averitt, John Hanna, and Jane T. Carlton. Data as of March 1, 1946. Two sheets, each 48 by 39 inches. Scale, 1: 2,500,000. Colored. Shows oil and gas fields, oil and gas pipe lines, and principal refining centers. Washington: U. S. Geological Survey, 1946.

United States Federal Power Commission. "Principal Natural Gas Pipe Lines in the United States and Communities Served With Natural, Manufactured, and Mixed Gas." Based on maps and reports filed with the Federal Power Commission. 41 by 53 inches. Scale, 1: 3,800,000. Colored. Inset maps of "Pittsburgh and Appalachian Region," "Monroe Field," and "Los Angeles and vicinity." Includes indexes of operating companies and principal holding companies. Washington: U. S. Government Printing Office, 1947.

The Oil and Gas Journal. "Natural Gas Pipe Lines of the United States." Supplement to the "Oil and Gas Journal" issue of September 20, 1947. 33½ by 45 inches. Colored. Shows natural-gas pipe lines and "major sources of gas." Lists principal natural-gas transmission companies in United States. Tulsa, Oklahoma: The Petroleum Publishing Company, 1947.

"Natural Gas Pipe Lines in the United States." Published by "Gas Age." Source of data: Federal Power Commission. 18 by 28½ inches. Scale, 1: 6,250,000. Colored. Shows major and minor gas producing areas as well as pipe lines. Has index of operating companies. New York: E. Holly Poe and Associates, 1947.

"Oil and gas map of Texas, Louisiana and Mississippi Gulf Coast." 42 by 74½ inches. Scale, 1: 675,000. Blue line print. Shows oil and gas fields, pipe lines, refineries, natural gasoline plants, recycling plants, and dehydration or repressuring plants. Lists refineries, plants and other "factual data" at bottom of map. Houston, Texas: Lee Jerome Wilson.

Stamp collectors, in particular, and map-lovers as a group, will welcome Ernest Dudley Chase's "Stamps of America, the Pictorial Map Dedicated to Philatelists Everywhere." (Copyright 1947, Ernest Dudley Chase, Winchester, Mass.; Research by Charles Peck Kerr.) Pictured on the face of the map, and arranged around its margins are facsimiles of the various postage stamps issued in the United States during the past 100 years. Interspersed with the stamp facsimiles are small sketches of early and modern post-offices, or scenes of historic events related to postal history, as well as interesting stamp facts. In keeping with the general theme, the borders of the map and the outlines of the U.S. and the individual states are drawn to resemble stamp performations. The map background is done in sepia tones, with the stamp facsimiles and sketches in black and white. The red compass rose and border add a touch of color. This map measures 20 by 32 inches.

For the past 20 years or more, Erwin Raisz has been producing physiographic maps or, as he prefers to call them, "landform maps." He has done much to popularize the technique of perspective sketching for showing relief on maps. Developed originally to

portray physiographic features, the "landform" maps appeal also to the non-technical map user. The pictorial presentation of relief forms suggests the actual landscape and enables even the casual map user to visualize the terrain. During the war, "landform maps" were used as the basis for strategical planning, and in post-war military planning the demand for such maps is still apparent. Thus, Raisz' latest effort, the "Landform Map of Alaska, (1948)," was prepared for the Office of the Quartermaster General, Department of the Army, and printed by the Army Map Service. The map measures 32 by 38 inches and is on a scale of 1: 2,500,000. Notwithstanding the small scale of the map, a great amount of detailed relief is shown by sketch lines and shading. Figures indicate elevations of prominent peaks. The shading for certain of the major ranges is quite black, and names and elevations are often difficult to distinguish. In general, the map is not as well executed as Raisz' "United States." It is, however, a significant cartographic contribution for our strategic Arctic territory.

"Meteorological Services of the United States" are shown on a recent map published by the Weather Bureau, U.S. Department of Commerce (Washington, 1948). Indicated on the map are location and type of airway, synoptic and supplemental weather reporting stations operated by the U.S. Weather Bureau, the Civil Aeronautics Administration, the Army, Navy, and Coast Guard, and other agencies; international, state, and airway forecast centers; flight advisory weather service units; Weather Bureau regional headquarters; airport stations and city offices, whether situated on or off the civil airways of the United States. Fourteen inset maps locate stations in and near large urban centers of the country. The map is on a scale of 1: 5,000,000, and measures 25 by 39 inches.

Another official map publication which should have widespread interest is the "Generalized Map of Soil Erosion in the United States," issued by the Soil Conservation Service, U. S. Department of Agriculture in July, 1948. Three contrasting colors differentiate erosion areas as *slight* or *none, moderate* (25 to 75 percent of top-soil lost, may have some gullies), or *severe* (more than 75 percent of topsoil lost, may have numerous or deep gullies). The map measures 14 by 21 inches and is on the scale of 1: 9,000,000. Soil Conservation Districts are also outlined on the map.

—Walter W. Ristow

❦ ❦ ❦

Variation of the Needle

FEW ARE AWARE of the great and continued variation from the true meridian of the compass needle. Observations on the subject should be often made and promulgated for the benefit of surveyors.

Having been obliged, this 25th Nov. 1856, to revise a line located by me due North, as the needle then pointed, Sept. 18, 1823, now 33 years and 68 days since, I find it has varied yet further West in that time, 2 deg. 53 min. 55 sec., or at the average rate of 5 min. 14 sec. a year, or 86-100ths of a sec. a day. The whole variation from the meridian is now 5 deg. 100 min. West. From these data I make the needle to have been truly on the meridian, 1st Oct. 1797, and varied 5 min. 14 sec. a year more westerly ever since. The variation in the line I mention above is full 2 rods in 40 further West, yet both lines true North as the needle points. No wonder there should be such confusion made in the surveys of farms.—W. C. P., *Land-Office, Pierrepont Manor, Jeff. Co., N. Y.*, November 25, 1856.

Books in Review

PRACTICAL ASTRONOMY FOR ENGINEERS. Graydon T. Horton. *Privately printed,* Toronto, Canada. 1948.

Reviewed by CHARLES A. WHITTEN, Chief, Section of Triangulation, Division of Geodesy, U. S. Coast and Geodetic Survey, Washington, D. C.

THE AUTHOR, a lecturer in the Civil Engineering Department of the University of Toronto, presents a new treatment of the computational part of engineering astronomy. Tables of the American Nautical Almanac are used as the basis for all computations. Greenwich hour angle is used rather than right ascension in these tables and the author develops the methods for computation using Greenwich hour angle without finding it necessary to refer to right ascension. This treatment of the subject will simplify the problem for engineers who have not been trained in geodetic astronomy or who have had no previous experience in that field. The proposed changes in the format of the ANA which will become effective in 1950 will require only a few minor revisions in the text.

The material has been well organized, being presented in ten chapters beginning with the elements of the celestial sphere, defining the various relationships between the observer and the lines in space, and concluding with detailed descriptions of the methods of observation and computation for time, longitude, latitude, and azimuth.

Mr. Horton has presented the material for his text in a very logical sequence. There are only a few instances in which further clarification could have been made. He has been very careful in discussing the effect of errors, either from instrumental sources or from the strength of the astronomical triangle. His differential equations are correct, but I cannot agree with the conclusions which he draws from some of them. For instance, in the discussion of the selection of best conditions for observing time, he shows that the error in time may be expressed as $dP = \frac{\cos h}{\cos d} dZ$. The author states this expression will become a minimum when the declination of the stars is near 0°. This is not correct. The expression minimizes when the altitude approaches 90°; therefore, the most favorable stars for observing time would be those with high altitudes. There is a similar error in the discussion under longitude observations. With correct treatment, these differential equations give the engineer a better understanding of the strength of the astronomical triangle.

Samples of computation with condensed instructions for observation and computation are included in each of the four chapters discussing the four different types of observation. This arrangement should prove to be very helpful, particularly for instructional purposes.

While there would not seem to be a great need for additional texts on practical astronomy, the explanation and treatment Mr. Horton uses for the Greenwich hour angle give his publication a place in the list of acceptable references and texts for engineers.

The publication has been printed by offset methods and is designed primarily for classroom use.

LEHRBUCH DER GEODÄSIE (Textbook of Geodesy). C. F. Baeschlin. *Orell Füssli Verlag,* Zürich, Switzerland. German Text. 1948. 892 pages. 65 Francs.

Reviewed by HELMUTH BAY, Rand McNally & Co., Washington, D. C.

THE Lehrbuch der Geodäsie, is not intended by the author, the internationally known Professor of Geodesy and Topography at the Technische Hochschule in Zürich, to be simply another standard handbook in geodesy. It is intended as an advanced aid for young geodesists to enable them to systematically study and understand the many new

theories and principles which are at present only to be found by consulting numerous scientific publications on the subject.

The methods of vector algebra are utilized throughout, but without neglecting the classical coordinate methods for subjects requiring their application. After a brief review of basic mathematical theories, classical and modern geodesy are dealt with, intentionally excluding geo-astronomical position finding and the computation of large triangulation.

The first portion of the work, seven chapters, presents geodesy from the geometrical viewpoint. It includes the geodesy of the spheroid, the theory of the deviations from the plumb line, and the theory of isostasy and its applications in computing the plumb line deviations from visible masses.

The second part, consisting of ten chapters, discusses the application of gravity measurements to geodetic determinations, particularly the utilization of such computations for the improvement of geometrical determinations of the geoid and of methods of levelling. One chapter deals with the theory of equilibrium surfaces of rotating fluids, the Eötvös torsion balance, and the drift of the Earth's axis.

❦ ❦ ❦

Flood Forecasting Made Easy

PEOPLE WHO LIVE in river valleys soon will get quicker warnings of threatening floods. The U. S. Weather Bureau will give the faster warning service by making nationwide use of its latest invention. Called the Electronic Flood Routing Machine, the device quickly and automatically computes the downstream effect of heavy inflow into any river or headwaters stream.

The machine's three inventors, R. K. Linsley, M. A. Kohler, and L. W. Foskett, utilized a long-recognized principle: The flow of electric current and the flow of water are analogous. Fundamentally, this means an electric circuit—its voltage, amperage, and resistance of its conductors—can impersonate the characteristics of flowing water. Machines that can produce this facsimile effect are called electric analog computers.

Here's how it's done in the case of the flood routing analog machine. Data on the inflow of the river (water pouring into it from tributaries or from rainfall) is supplied to the machine's input unit in the form of a graph. The graph in turn guides the operator in regulating an electric current. The electricity masquerades as the water flowing down stream, aping all of its characteristics. This electric current instantaneously produces another graph in the output unit. The latter graph gives an accurate preview of the river's height when it reaches downstream. At present such a flood forecast is manually computed.—*Science Illustrated,* December 1948.

❦ ❦ ❦

Photo Mapping of Pennsylvania Turnpike

PHOTO MAPPING of the eastern extension of the Pennsylvania Turnpike was completed March 29, 1948, within 5-months' time, by the Aero Service Corporation of Philadelphia. A contract for the mapping of an area 1 mile wide and 141 miles long, from a point near Carlisle to near Paoli, Pennsylvania, was awarded to the Philadelphia concern by the Turnpike Commission last October. The completed topographic maps, scale 1 inch: 200 feet and showing 5-foot contours, are being used by Gannett, Fleming, Corddry and Carpenter, well-known consulting engineers of Harrisburg, who have been commissioned to design the highway.

Aero Service delivered the first maps December 15, 1947, and made final delivery 100 days later. Had the survey been accomplished with conventional ground methods, approximately 2 years would have been required, compared with 5 months for aerial mapping.—*Photogrammetric Engineering,* June 1948.

CONGRESS NEWS

A Legitimate Protest

The following letter, which is self-explanatory, was sent by the Georgia Association of Registered Land Surveyors (the first such organization in the United States to join the Congress under group leadership) to J. C. Capt, Director, Bureau of the Census, Department of Commerce, Washington 25, D. C.:

"In view of past census classifications and the forthcoming business census for 1949, it is our desire as a united organization of professional surveyors, licensed to practice land surveying in the State of Georgia, to request that every consideration for the proper designation of the art of surveying be adhered to only as PROFESSIONAL in listing of SURVEYORS in the 1949 business census and all others thereafter.

"There are approximately 574 surveyors registered under the laws of Georgia at this time, with an estimated 50 percent depending upon surveying as a direct means of livelihood. In their behalf and in consideration of the technical education, experience, and ability necessary for the proficiency of this all-important profession upon which the efficient execution of so many engineering projects depend, it appears self-evident of its congruous place in a professional category. Further apparent logic of the surveyor's classification is evidenced by the courts of all states, and the (professional) lawyers requirement for the services of a registered surveyor in settlement of property disputes, thereby designating the surveyor as an expert witness.

"Doubtless, numerous comparisons are available, nevertheless we can only view and accept the art of surveying as one of highest calibre and achievement, and proclaim it a Professional Occupation.

"Your careful review and consideration of this matter, we believe, will unquestionably result in the reclassification of the surveyor in the professional group, thereby justifying an occupation of which realization of its importance cannot be publicly accepted in a semi-professional rating."

NEW MEMBERS

ABBOTT, AUBREY, Ware County Surveyor, P. O. Box 38, Waycross, Ga.

ABRAHAM, NASEEM N., Cartographer, 4239 1st St., S.E., Washington 20, D. C.

AVILA, VICENTE, Capt., Ave. Columbia y Espinosa 200, Quito, Ecuador

BARRETT, ERNEST W., 2208 Sixth Ave., Milwaukee 22, Wis.

BECKMAN, WALLACE J., Civil Engineer, 600 N. Second St., Harrisburg, Pa.

BELL, ROGER W., 515 N. Garfield Ave., Janesville, Wis.

BERRYMAN, WM. C., 1811 E. Michigan Ave., Lansing 12, Mich.

BODEMER, PHILIP E., 1109 N. Highland St., Arlington, Va.

CONDRA, CHARLES E., Civil Engineer, P. O. Box 27, New Albany, Ind.

DEAN, MINOR E., Engineer, P. O. Box 1429, Jackson, Miss.

ELLER, ROBERT C., Cartographer, 1820 Clydesdale Pl., N.W., Washington, D. C.

EMERY, SERGE A., Civil Engineer, 169 E. 2nd St., New York 9, N. Y.

FARLEY, ROBERT A., Civil Engineer, 13101 Courtland Ave., Cleveland 11, Ohio

GARDNER, FRED W., Engineer & Land Surveyor, 870 Main Ave., Clifton, N. J.

GEMUNDER, D. K., Land Surveyor, 11 Ladd & Bush Bldg., Salem, Ore.

GODFREY, DAVID D., 1930 Ridge Rd., Arlington, Va.

GREENAWALT, NORMAN E., 1404 N. Tuckahoe St., Falls Church, Va.

GREGORY, A. VAN NESS, Civil Engineer, General Delivery, Crossett, Ark.

HERMAN, E. J., Civil Engineer, 2201 N. Vermont Ave., Los Angeles 27, Calif.

HOXIE, BENJAMIN W., 3 Brookdale Rd., Washington 16, D. C.

KARRH, J. A., Blount County Engineer, 834 S. 81st St., Birmingham, Ala.

KNEZOVICH, FRANCIS M., Captain, 62nd Engr. Topo. Co., Fort Bragg, N. C.

KNOTT, ROBERT J., Engineer & Surveyor, Atlantic Refining Co., Box 2819, Dallas, Tex.

LADD, EDWARD J., Engineer & Surveyor, P. O. Box 66, Ft. Payne, Ala.

LAW, JOHN A., 6208–28th St., N., Arlington, Va.

LINEHAN, URBAN J., Prof., Dept. of Geography, Catholic University, Washington 17, D. C.

MARTIN, F. I., Chief, Land & Eng. Dept., Socony Vacuum Oil Co. of Venezuela, Apto. 1193, Caracas, Venezuela

MESS, MARGARET E., 1477 Harvard St., Washington 9, D. C.

MILES, PHIL. M., 229 Barrow Rd., Lexington 28, Ky.

MILLER, SAMUEL B., Cartographer (U.S.C. & G.S.), 641 Washington St., New York, N. Y.

MORRIS, FRED C., Prof., P. O. Box, Blacksburg, Va.

NUNEZ, LOUIS A., Lt. Col. Ave. Colon No. 2271, Quito, Ecuador

O'KEEFE, MARTIN S., JR., P. O. Box 1200, Bakersfield, Calif.

REED, RALPH S., City Engineer, Watertown, S. Dak.

ROSALES y R, OSCAR EUDORO, Civil Engineer, 2ª Aveninda Sur No. 41, San Salvador, El Salvador

ROSS, LEROY E., Box 133, USGS., Rolla, Mo.

SCHREITER, JESSE B., 94 W. Como Ave., Columbus 2, Ohio

SCOTT, ROLAND F., c/o Clark Library, 2205 W. Adams St., Los Angeles 7, Calif.

STEINKAMP, J. C. HAROLD, Surveyor, 1219 Yonkers Ave., Yonkers, N. Y.

TARPEY, HUGH M., 2122 Buena Vista Ave., Alameda, Calif.

TIDDENS, PAUL T., 9610 S. Troy Ave., Evergreen Park, Ill.

TWOMBLY, JAMES L., 512 Timber Lane, Falls Church, Va.

LIBRARY MEMBERSHIPS

•

AERIAL SURVEYING SECTION,
OHIO DEPARTMENT OF HIGHWAYS
868 W. Goodale St., Columbus, Ohio

•

CHUBB LIBRARY, OHIO UNIVERSITY
Athens, Ohio

FONDREN LIBRARY, SOUTHERN METHODIST UNIVERSITY
Dallas, Texas

•

LIBRARY, MICHIGAN COLLEGE OF MINING AND TECHNOLOGY
Houghton, Mich.

•

LIBRARY, MICHIGAN STATE COLLEGE
E. Lansing, Mich.

•

LIBRARY, NATIONAL TAING HUA UNIVERSITY
Peiping, China

•

LIBRARY, OTAGO UNIVERSITY
Dunedin, New Zealand

•

LIBRARY, WEST VIRGINIA UNIVERSITY
Morgantown, W. Va.

Reclamation Activities in Alaska

THE BUREAU OF RECLAMATION has established an investigations office at Juneau, Alaska, headed by electrical engineer Joseph M. Morgan who will explore the water power possibilities of the Territory with a view to future expansion of settlement and industrial development.

These studies were made possible by an appropriation of $150,000 granted to the Bureau for the work during the fiscal year 1949. Reclamation's survey of the water resources will round out a program already under way by other Interior agencies on mineral, geologic, fisheries, wildlife, and other resources designed to enrich the multiple-purpose development in Alaska.

The existing shortage of electric power makes these investigations necessary for industrial expansion and settlement. One of the most pressing problems to be considered will be development of a power supply at Eklutna Lake to provide adequate resources for the city of Anchorage, for the electric cooperatives in Matanauska Valley, for the Alaskan Railway, and for Indian Service installations.

Other studies will include Juneau, Sitka, and Ketchikan. Development of a suitable power supply at Ketchikan would be designed to assist materially in creation of a pulp industry to alleviate newsprint shortages faced by the American public today.

Engineer Morgan will be assisted by Richmond C. Johnson, formerly area engineer for the Bureau at Salt Lake City. The staff consists of a hydrologist, geologist, field engineers, and a draftsman. This is the first work that the Bureau of Reclamation has done in Alaska.—*The Reclamation ERA*, September 1948.